

83D 14-10
NASA Conference Publication 2155

NAS 1.55: 2155
ORIGINAL

Field Study for Remote Sensing

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96

An Instructor's Manual

Proceedings of the
Landsat C Educator's/User's Workshop
held at Santa Maria, California
March 2-4, 1978

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Field Study for Remote Sensing

An Instructor's Manual

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Proceedings of the Landsat C
Educator's/User's Workshop
sponsored by the National Council for
Geographic Education, Western Illinois University,
Macomb, Illinois, and NASA Ames Research Center,
Moffett Field, California, and
held at Santa Maria, California
March 2-4, 1978

NASA

National Aeronautics
and Space Administration

**Scientific and Technical
Information Branch**

1981

Library of Congress Card Catalog Number 78-61696

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Elementary students (Fifth Grade Class, Hort School, Bakersfield, California) learning surface truth techniques in a field adjacent to their school.



Landsat C Workshop participants at a surface truth site.

PREFACE

Scientists have stated that aerial photograph interpretation is meaningless without ground observation verification. People who work with aerial photographs know that if images of such features as corn, wheat, buildings, and other natural and cultural phenomena cannot be recognized on the ground, the likelihood of identifying them on an aerial photograph is severely minimized. Even with the use of large scale aerial photographs, planning analysts are constantly faced with the problem of not being able to identify an image on an aerial photograph with certainty, and they are forced to travel to the site on the ground to make a positive identification. Field work, notwithstanding our modern, spectacular progress in remote sensing, is still necessary in accurately interpreting aerial photographs because of the small scale of the photograph and because of the vertical, and therefore unfamiliar, orientation from which it was made. The problem of accurate image identification of Earth features has been compounded as high altitude, suborbital, and space imagery have become available to the community of scientists who are engaged in identifying crops, forests, urban communities, transportation systems, water features, pollutants, and landforms. Whereas size, shape, and pattern can be used to identify many features from aerial photographs, the new science of accurately identifying features from images taken at high altitude suborbital and orbital altitudes has increased the dependence of the interpreter on color, tone, and texture for interpretation. Association of features, however, remains an important parameter in the accurate identification of images from all altitudes — from only a few thousand feet to many hundreds of miles above the Earth.

Field work remains basic to accurate interpretation of images produced by remote sensors carried by high altitude aircraft or by space satellites. Field work, or surface truthing,¹ involves on-site investigation by the researcher. The interpreter may have to prepare reconnaissance maps in the field or take ground photographs of features under investigation for reference in the office. The investigator may find it advantageous to fly over an area under investigation at low altitudes in order to combine the familiar oblique view with that of reduced scale in order to identify objects and to interpret associations. Low altitude aerial observation and photography may be considered as much a field technique as actually hiking on the ground; and it yields results in shorter periods of time.

On the other hand, surface truthing (either on foot, by car, or from low altitude aircraft) of some areas may be precluded because of distance, or political or topographic inaccessibility. Field work in these cases may have to be performed in training sites or "windows." Areas of known features are selected. Images of these features are observed and identified on high altitude aerial or space frames. When similar patterns, tones, textures, and associations appear on images where field work is impossible, reasonably accurate identification may be accomplished.

Field work for aerial and space-imagery identification may be more sophisticated than an individual's ground observation alone. It may take the form of establishing packages of transmitting instruments in training sites. Information on such environmental parameters as temperature, humidity, winds, reflectance, radiation, water levels, and soil moisture may be recorded for use in the identification of conditions, events, and features in the scene. In some cases these instruments are

¹The term "ground truth" is being supplanted by "surface truth" since the launch of SEASAT-A, June 27, 1975.

programmed to transmit information to Landsat vehicles as the satellite passes within range. The ground data are superimposed on the satellite data base and the product is delivered to the investigator for further interpretation.

It is not uncommon for the aerial photograph and space image analyst to establish interpretation keys. These keys may range from simple file cards to elaborate computer data bases. In the simplest form of key, images of objects under investigation are attached to file cards. These cards are indexed for easy access under designated categories, such as lineaments, crops, types of forest stands, outcrops, stream dissection, categories of buildings, or urban and industrial configurations. Elaborate keys may include a combination of space images, high altitude infrared images, and computer data of the same area. In all cases the information of the key has been validated on the ground. The purpose of the image key is to provide accurate, known information about some category of earth features, events, or scenes. Then when similar image characteristics are observed on images of areas which cannot have surface truth established, a higher level of accurate identification can be achieved than when no field observations have been made or can be undertaken.

Surface truth, field work, ground study, or whatever the procedure is to be called, is essential to accurate identification of scenes or events which appear on space images. The interpretation of these images requires special in-depth training in a discipline as well as in interpretation techniques. Much of this training must involve the correct types of procedures to be used for field checking in the shortest amount of time, with the least cost, and with the greatest accuracy.

Most educational institutions which offer advanced work in aerial photograph interpretation, photogrammetry, and remote sensing are aware of the need for and value of field work in the analysis of aerial and space images. In an effort to maximize recognition of the need for and the value of field work in remote sensing of the environment, the National Aeronautics and Space Administration (NASA), the National Council for Geographic Education (NCGE), and the California Council for Geographic Education (CCGE) sponsored an in-depth training session in the interpretation of high altitude aerial photographs and Landsat imagery on March 3-5, 1978 at Santa Maria, California. The conference/workshop, under the cochairmanship of Garth A. Hull (NASA Ames Research Center) and William H. Wake (California State College, Bakersfield), was attended by more than 300 educators and scientists, and was planned to precede the launch of Landsat 3, the third and most sophisticated of the Landsat series of Earth resources reconnaissance satellites.

The workshop was successful because it incorporated the necessary ingredients of aerial and space imagery interpretation for educators who were being introduced to remote sensing as well as for experienced users of imagery. The success of the conference can be measured by the fact that it not only established a model for other space-image interpretation conferences, but it also illustrated how such a program on space technology could be incorporated into classrooms and laboratories in all types and levels of instruction. Young people today are going to spend the remainder of their lives in a world where information about the Earth and its resources will be obtained from space sensors. It is important that educators can adequately instruct in these facets of resource monitoring. A conference such as the one conducted in March 1978 instilled confidence and enthusiasm in the educators and users present, and it is hoped that they will be able to parlay this to their students and trainees.

The Landsat conference classroom lectures, laboratory, and field sessions were climaxed by the successful and spectacular launch of Landsat 3 at 9:54 a.m. (PST) from NASA's Western Test Range near Lompoc, California.

Not every remote sensing conference can end with such a spectacular and awe-inspiring event, but future remote sensing conferences, and classes as well, can use this conference and the materials contained in this handbook as a guide for developing instructional and research procedures in remote sensing of the environment; not the least of which is the need for and value of field work (surface truthing) in the verification of image identification from high altitude infrared and multi-spectral space sensor images.

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SPECIAL ACKNOWLEDGMENTS

We, the editor and contributors, especially thank Garth A. Hull and B. Michael Donahoe, National Aeronautics and Space Administration (NASA) Educational Program Officers, Public Affairs Office, NASA, Ames Research Center, for their encouragement and assistance in planning and presenting the Landsat C Workshop, and Mr. Hull for his assistance in completing this manual; Dr. Frederick B. Tuttle, Director of NASA Educational Programs, Washington, D.C., and Bennie D. Padrick, Chief, NASA Western Regional Applications Office, Ames Research Center for their support of the workshop and manual; Eugene C. Napier, Representative, and the staff of the Western Region Office, United States Geological Survey (USGS) Geography Program for compilation and reproduction of the 1:24,000 Level 2 Land Use Classification Map of Santa Maria; James R. Wardlow, Senior Soils and Water Analyst, Division of Planning, State Department of Water Resources (DWR) for the 1:62,500 Level 2 DWR Land Use Classification Map; Dr. Richard Ellefsen, Director, Cartography and Remote Sensing (CARTREMS) Laboratory, San Jose State University for the production and distribution of the 1:2400 Level 3 Land Use Classification Map of the Polis Site and the Graphic Planimeters; James C. Wardlow, United States Bureau of Land Management (USBLM) for compilation of the 1:250,000 Soils Map of the Santa Maria Area; Det. 8, 37th ARRS, Vandenberg Air Force Base, for permitting staff assistants to accompany a training flight and take low oblique photographs of the four sample window sites; Dr. Benjamin F. Richason, Jr., Chairman, National Council for Geographic Education (NCGE) Remote Sensing committee, for his advice and assistance with the workshop and manual; Dr. Karl A. Robert, President, Dr. Charles F. Gritzner, Executive Director, and Lori Meredith, Office Manager, NCGE, for their encouragement and assistance; Dr. Thomas D. Best, President, and Dr. Haig A. Rushdoony and Dr. William J. Frazer, Executive Secretaries, California Council for Geographic Education (CCGE) for their assistance with the workshop; and Janet Pierucci, California State College, Bakersfield (CSCB) Office of Continuing Education. Finally, we thank the NASA Educational Program Staff for their careful review of the manuscript.

William H. Wake, Editor

AN INDUSTRIAL PERSPECTIVE OF THE LANDSAT OPPORTUNITY*

Barbara E. Williams**

I know for some of you the thought that industry might have a perspective on the Landsat opportunity is cause for trepidation. However, let me put your mind at ease. The perspective is my own. I cannot speak for the corporation by which I am employed, I cannot speak for the industry of which it is a part, and I certainly cannot speak for industry overall. But I can speak to all three, just as I speak now to NASA and to you, who, by your presence, have established an interest in Landsat that should be shared by *all* segments of our society, including industry. Landsat has the potential to have as prevailing an impact on our lives as the modern computer has had and continues to have. In fact, the computer industry probably provides the closest analogy to the Landsat opportunity.

In 1951 Remington Rand installed the first production line computer, Univac 1, in the Bureau of the Census. In 1954 the first computer for commercial applications, a Univac 1, was delivered to GE's new appliance plant in Louisville, Kentucky. By the end of the decade the number of installations increased to approximately 6000.² But it took another decade before the industry matured to the point that it was no longer technology driven and the user became the driving force. Landsats 1 and 2 are analogous to Univac 1; Landsat 3, being launched in a day and a half, will no doubt expand the number of users well beyond the 6000 computer installations of the 1950's. However, we cannot afford to allow 20 years to elapse before user and usage needs become the driving factors in the development of an operational Landsat system and the associated technologies.

I think the dilemma of today has been admirably expressed by an artist with an illegible signature in a lithograph entitled "Peace." On it is printed, "While our environment needs our most serious attention, I just can't believe that doomsday is just around the corner. However, it would be great if we could, each one of us, get so far ahead of everything considered bad that generations to come will know that we cared and loved all."

Well, I don't believe that doomsday is just around the corner either. But I do believe that Landsat cannot only help to change that thought from contemplation to reality, but that it can also broaden the scope from "each one of us" to every one of us. And the "every one" market is one that industry cannot afford to ignore nor can it afford to ignore industry. But progress through Landsat in getting "ahead of everything considered bad" won't happen if we sit and wait. We must take positive action. And that is what I'd like to propose to you this evening, one course for positive action.

*Keynote address to the Landsat C Educators and Users Conference, Santa Maria, California/NASA Western Test Range, March 3, 1978.

**Formerly: Presidential Interchange, Executive Manager, Market Requirements & Planning, Landsat Follow-on Program, NASA User Affairs Division, Office of Applications. Currently: Program Manager, New Product Introduction, IBM Corporation-General Business Group/International, White Plains, New York.

²A *Computer Perspective* by Charles and Ray Eames.

In most instances, a product is developed to fill one or more identified needs and then marketed to potential users. In the case of Landsat, the product, albeit in somewhat of an experimental state, existed prior to recognition of need and, in addition, belonged, quite rightly, to the entire American public through the Federal Government. Normal market development and product development techniques could be applied. And yet, making utilization of Landsat data a nationalized industry would not be an acceptable solution. To paraphrase Winston Churchill, the free enterprise system is the worst system on earth, except all others. The challenge of how to resolve these conflicting factors has existed for NASA from the beginning and continues to exist, although progress is now being made.

This workshop, preceding the launch of Landsat 3, is part of that progress. As NASA, through its regional technology transfer centers, educates the public in general, and potential Landsat data users in particular, in the possible applications and benefits of Landsat data, the need for specific products and services will be identified. And since, here in the Western Region Applications Program, all sectors of society — government and private, user and supplier, and academic and individual — are involved, the market should develop without alteration of traditional relationships. It is fulfillment of that market that is of growing concern.

One of the concerns can be easily put to rest. So let me dispose of that one and then deal with the nuttier problems. There are those who fear that the satellite information volumes will overwhelm computer capacities and would therefore limit the capabilities of future operational systems. Such a viewpoint shows a gross misunderstanding or underestimation of the computer industry. The law of demand and supply operates as effectively in the data processing industry as anywhere. In an industry where the current applications bottleneck is input/output, manufacturers are not going to rush to increase computer power and main storage. But if the need were there, it is my conviction the capacity would be also. In the past 25 years raw computer power (measured in millions of instructions processed in 1 second or MIPS) has multiplied 500 times (an average of 20 times per year) and user storage capacity 4000 times (an average of 160 times per year). The full capacity of Landsat D would only require that a ten multiplier be applied to today's capabilities — a realistic expectation for the 1980's if the demand were there. In fact, I'd personally speculate that the ability exists today in many research laboratories. But even if such speculation were unjustified, we should not, we must not, limit tomorrow's systems to yesterday's deliverables.

Some approach a problem with the question, "can it be solved?" Others approach the same problem with the conviction, "it will be solved!" It is where there is a will that there is also a way. And it is with this conviction that I approach the larger problems in providing Landsat data as free from usage limitations as possible on a least-cost basis.

There is a basic premise in the proposal I shall make. Greatest usability-least cost is best served by refinements in the raw data. Even if the cost of a computer tape or a composite were to double current projections, the savings in the information extraction and analysis alone would justify the increase, not to mention increased utilization of the information due to reduced turnaround time and greater accuracy. The improvements I speak of essentially mean improvements within the spacecraft. Improvements, such as accounting for sun angle change, the use of pointing accuracy to make geometric corrections, and possibly making radiometric corrections, all on board the spacecraft. These are improvements in the quality of data and are therefore prime spacecraft candidates rather than such things as data reduction or information extraction, both of which assume a prior knowledge of application and correspondingly reduce potential utilization.

Are these enhancements viable, or even feasible? I don't know. But I propose that we find out, and not on the basis of lowest bidder or a research grant. But rather through Government sponsorship and finance of one or more task forces composed of a critical mass of experts in multiple disciplines from multiple industries and academia. The objective is to achieve the synergism of multiple minds addressing singular problems without the creation of permanent or perpetual structures. But, and this is a crucial "but," the output must be in the form of implementable specifications, even if presented as alternatives. This will achieve greater cost effectiveness and shorten the cycle to implementation.

This same approach should be applied to other challenges related to data usability but not on board the spacecraft itself. They include such things as:

- Investigation of the use of multilinear arrays
- Determination of how sensor calibration should be done
- Determination of the effects of atmospheric inversion
- Determination of the best way to back out the modulation transfer function.

All are highly technical considerations, but all have a bearing on how usable the data are for what applications.

There is no nation with a greater capacity for achievement than our own. Well, let's put that capacity to work. If the problems associated with usability of data were solved and if user awareness were achieved, then the production of cost justifiable processing equipment and services becomes the responsibility, the obligation, and the opportunity of industry at its competitive best, be it "big business" or a one-person shop. There can be no handouts, and industry must make the final investment on its own.

Through Landsat, NASA has made its most significant step in the fulfillment of the second half of its charter; the first half being to go into space, and the second being to make the benefits of space available to mankind. This step may well be the nation's most significant achievement. Referring back to my original analogy between Landsat and the computer, I'd like to quote the findings of Charles and Ray Eames. They found that even those closest to the computer were unprepared for what happened. To quote them, its "spectacular growth -- in numbers, in capacity, in application -- came as one of the greatest surprises of modern times."

What may not be surprising, but can be heartening, is that "the computer appears to be the result of many people trying to solve many problems in many fields -- as a natural consequence of getting on with the business of life in general."

Well the growth of Landsat data users probably will come as no surprise, and no doubt any inherent problems could and would be solved in much the same way as those of the computer. But must we wait; can we afford to wait? Can we afford to put the cost of individual research and development into the cost of end-user processing? Must each user individually pay for the semiresolution of problems that are common to all users? Can we afford not to reap the full benefits of Landsat? I say emphatically, "No, we cannot!"

Government and government, industry and government, work well together in defense. Now is the time and Landsat is the opportunity to truly turn our swords into plowshares.

Chapter 1

THE WORKSHOP

William H. Wake*

INTRODUCTION

In her Landsat C Workshop Keynote Address, Barbara Williams presented an exciting perspective on the future use of Landsat imagery. That future requires a very large number of users educated to, and trained in the use and application of Landsat data. They must also be competent in the use of a wide range of other remotely sensed imagery and data for environmental analyses and the solution of problems arising from the use and misuse of our environment. The Landsat C Educational workshop was designed to provide a technology transfer – educational and training experience for the 341 attendees that would help to prepare them and others through them to participate in the exciting future Ms. Williams described.

OBJECTIVES AND GOALS OF THE WORKSHOP

The objectives of the workshop were to: (1) present a program which would provide a valuable educational and training experience in the reading, interpretation and application of Landsat and correlated larger scale imagery, digital printout maps, and other collateral material for a large number of participants with widely diverse levels of expertise, backgrounds, and occupations in government, industry, and education; (2) increase the participants' knowledge of the characteristics and applications of Landsat and other remotely sensed data; (3) expand the participants' capabilities to apply Landsat and other remotely sensed data to the solution of real world problems; (4) provide educators, government, and industry personnel at all levels with a set of effective instructional strategies and instruments that could be replicated for use in a wide variety of educational/training programs; (5) demonstrate the need for and use of surface-truth field studies with correlated aerial imagery in solution of real world problems; (6) demonstrate the use of surface-truth field problems and field-related laboratory problems in interpretation and application of education/training programs.

The goals of the workshop were to: (1) increase the number of professional users of Landsat data; (2) enhance the capabilities of persons already using remotely sensed data in industry and government positions; (3) increase existing knowledge of remote-sensing teaching materials and strategies among persons with educational and training responsibilities; and (4) increase public awareness of the value and uses of Landsat and other remotely sensed data.

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PLAN OF THE WORKSHOP

The plan of the two-day workshop was developmental. A series of illustrated lectures on the major aspects of Landsat imagery characteristics and use provided a foundation for surface-truth field trips to four window sites. At each of the four window sites specific environmental analysis problems were addressed in the field and in the following field-related laboratory session.

The developmental learning plan of the workshop may be replicated for remote sensing workshops and courses dealing with any topic or set of topics on either a comprehensive basis like the Landsat C Workshop, or on a specialized basis such as water resources or forest and range resource management, at any level, of longer or shorter duration, in any locality.

The sequence of the two-day plan was based on five stages of development:

1. March 2: Registration — With pre-registration by mail, most of the participants completed registration formalities at an informal "get acquainted" session the night before the start of the workshop. Here they could meet and exchange ideas and information with the faculty and one another; obtain their instructional materials kits and the supplementary information kits with materials provided by NASA, the USGS, and several industrial participants; obtain copies of MISSION TO EARTH: Landsat Views the World; and view exhibits.

2. March 3: Plenary session on characteristics of Landsat hardware, software, and programs.

3. Plenary sessions on reading and interpreting imagery by (a) visual (manual) inspection, (b) instrumented interpretation.

4. Visual and instrumented applications by (a) disciplines (three concurrent sessions), (b) government agencies and industry (plenary sessions and two concurrent sessions), (c) educators at elementary, secondary, and higher education levels (three concurrent sessions simultaneous with the group (b) concurrent sessions).

5. March 4: The Hands-On Workshop — (a) Orientation sessions to present the characteristics and bases of selection of the window test sites, visual interpretation and applications of U-2 imagery of the window sites, and instrumented interpretation and applications of Landsat imagery of the Santa Maria area, (b) surface-truth field trips with problems to be worked in the field, and (c) field-related laboratory problems.

Because of heavy rains the morning field trip time was utilized for an extra laboratory period. Clearing weather permitted an abbreviated afternoon field schedule with visits to each window shortened by about one half the time which had been allotted in the original schedule. The extra laboratory time partially compensated for the loss of field time through the use of low, medium, and high altitude imagery and maps of the window areas and an expanded orientation session.

The Launch Orientation evening program, attended by the workshop participants plus 276 additional persons, repeated to some extent materials covered in the workshop which provided reinforcement for workshop participants and acquainted launch viewers with some of the

characteristics and capabilities of Landsat imagery. (See appendix A for the complete workshop schedule.)

A workshop evaluation questionnaire was sent to all participants some months after the workshop to obtain more reflective responses than were possible at the time. (See appendix B.)

PARTICIPANT REGISTRATION

The 341 registered participants represented a wide variety of background, expertise, and occupational interests and included state legislators, government agency and industry employees, as well as educators from the elementary levels through higher education. Californians rather expectably dominated with 312 participants, but seventeen other states from Georgia to Hawaii and two Canadian provinces were represented by 29 persons.

Four registration options were offered: Option I – admission to the workshop, no credit; Option II – continuing education (CEU) professional improvement credit; Option III – continuing education (CEU) in-service teacher credit; Option IV – upper division/graduate Earth Science credit through the office of Continuing Education, California State College, Bakersfield. Only Option IV unit credit was transferrable and applicable to academic degree or teaching credential programs. All options were approved by the Dean, School of Natural Science and Mathematics as well as the Dean, Continuing Education to ensure their meeting campus and accreditation standards. (See appendix C for numerical distributions.)

FACULTY, STAFF, AND SPONSORSHIP

The 37 faculty members were drawn from government, industry, and education. They were assisted by two lecturers and 28 student assistants from the Geography Remote Sensing Unit, Department of Geography, University of California, Santa Barbara, and five from the Department of Physics and Earth Sciences, California State College, Bakersfield. (See appendix D.)

The workshop was sponsored and developed by the National Council for Geographic Education, California Council for Geographic Education, the National Aeronautics and Space Administration Educational Programs, and Western Regional Applications Programs. Publicity support was extended by the California Science Teachers Association and the National Council for Geology Teachers, Far Western Section. The Planning Committee members take this opportunity to express our sincere thanks to the co-sponsors and supporting organizations for making the workshop possible.

Chapter 2

WHY SURFACE-TRUTH FIELD STUDY IS NEEDED IN REMOTE-SENSING

INSTRUCTION

William H. Wake

WHY SURFACE-TRUTH FIELD WORK IS NEEDED IN REMOTE-SENSING INSTRUCTION

Surface-truth field work is needed in instruction to improve the quality and speed the process of learning and to equip students to meet employment requirements. Although the impressive growth of remote-sensing and interpretive capacities has led many to conclude that field work is no longer necessary, especially in educational/training programs, just the opposite is true in every discipline that uses remotely sensed data. The research – underlying each new type of imagery, quality improvement of existing imagery and related data, interpretive technique or instrument development – has been based in significant part on surface-truth field studies to establish levels of resolution and interpretive/applicational accuracy and validity. Likewise each industry or government agency project that applies the findings of research to solve real world problems automatically includes surface-truth field sampling to establish data interpretation reliability levels for the area involved in the project.

Surface-truth field studies are recognized as mandatory in nearly all research problems and applied projects using remotely sensed data to analyze characteristics, features, patterns, relationships, and interactions of the natural environment, environmental uses, and their effects. Why is it not equally true that surface-truth field studies are automatically included in remote-sensing technology transfer education and training workshops, courses, and government/industry in-house programs?

Various reasons are given for the omission of field work from remote-sensing technology-transfer programs, but they are invalid or illogical, including the often heard complaints of legal and logistical restrictions, lack of time in existing program frameworks, or the claim that the students/trainees get adequate field training in other courses in their major and other disciplines.

Especially designed field studies are needed in remote-sensing technology transfer courses regardless of the field work provided by the students/trainees major disciplines because the remote-sensing discipline has unique emphases and needs. Legal/policy and logistical restrictions can be met by proper window site selection. Inclusion of field studies in the technology transfer program not only increases the quality of learning but speeds up the process. Therefore modification of existing schedules to include field work provides the equivalent of extending the duration of the program with the added benefit of enhancing learning achievements per actual program day.

Further, basic logic should clearly indicate the need for field studies as part of the learning process in the use of remote sensing data. After all, the basic purpose of using remotely sensed data is to provide knowledge and understanding of things that occur in the field. Therefore, it is only

logical to look at things in the field as part of the process of learning how to use the imagery, maps, and other remotely sensed data products.

The fact that not all surface-truthing requires field site visits has been perhaps the single most important factor in forming the opinion that field work is not needed in the education and training of remote-sensing interpreters. For users of low-altitude photography, the scale and resolution of imagery almost eliminates the need for on site ground identification. The State Water Resources Control board, for example, has found that on site field visits are needed to identify only 10% of the water quality and water-pollution-control violations in areas covered by low-altitude photography.³ However, the importance of accurate identification of that 10% of coverage is critical. Therefore, interpreters still need to have their field competence developed in their training programs.

Further, the use of low-altitude photographs to provide surface-truth for U-2 imagery, and the use of U-2 imagery to surface-truth satellite data,⁴ still depend on field site/sample identification to establish complete surface-truth accuracy. Thus, each increment of multialtitude, multiscale, and multiimagery interpretation is actually an extension of the field-study concept and increases the need for remote-sensing interpreters to have built a solid foundation of field work in their education and training.

Field experience at any level in any discipline does increase student/trainee capabilities at all subsequent levels and in any field-related discipline because all field work has a common basic goal – to help the student/trainee effectively see more of what is looked at. However, no level of instruction or discipline can rely exclusively on field work at earlier levels or in other disciplines to meet its needs because each has unique emphases, needs, and capabilities. For example, physical geography or geology students will improve their general ability to use their eyes on a sociology or history field trip; but how much specialized physical geography or geology field expertise will be developed? The discipline of remotely sensed data interpretation and application is as unique as any other discipline in its specialized emphases and processes.

THE PROCESS OF SURFACE TRUTH FIELD INSTRUCTION

The process of surface truth field study is based on the four stages of imagery and map use: (1) Simply *look* at the imagery and maps – a reflexive act for basic orientation; (2) *read* the image signatures and map symbols – find the geographic facts; (3) *interpret* the spatial and other relationships and their significance – find the conceptual content of the data; and (4) *apply* geographic, environmental, and land-use concepts and principles to the interpreted data to solve problems.

The learning sequence in this progression of use of data is based on the correlation of the appearance of objects in the field with their imagery signatures and correlation of both with their map symbols and other data. These correlations, in turn are based on the technology transfer of

³Fraga, G., Remote Sensing Coordinator, State Water Resources Control Board, Sacramento, California, personal communication.

⁴Gaydos, L., USGS-NASA Geography Program, Ames Research Center, personal communication.

recognition of field objects to identification of their imagery signatures and map symbols, to development of their significance as landscape items, and to delineation of their role in the landscape.

The technology transfer from field-object recognition to imagery-signature identification is based on the elements of image interpretations of: size, shape, shadow, tone or color, texture, pattern, site, association, and resolution (Estes and Simonett, 1977, pp. 571-882). These elements (except for shadow, tone or color, texture, and resolution) also apply to map interpretation. Therefore, the use of maps along with imagery not only enhances the value of the surface-truth field study in developing site and regional information and imagery interpretation/application capabilities, it also helps to build needed map interpretation skills.

The details of developing meaningful surface-truth studies will, of course, vary widely according to the level, associated discipline, purpose, and even locality of the field work, and in response to budgetary, legal, and other factors external to the learning process. However, the fact remains that surface-truth field studies and problems are as mandatory in the process of learning to interpret and apply remotely sensed data in any discipline as they are in scholarly research and applied projects, and that they are equally valuable for all levels of education and training.

LEVELS OF STUDENT CAPABILITIES

Experience has established that third grade students can make effective use of low-altitude oblique and vertical black and white and color imagery and appropriately designed maps to learn about the natural environments they live in and help to use, and in learning about other environments and other types of environmental use. Fifth grade students (see fig. 1) can begin to make use of U-2 and Landsat imagery, color infrared, and side-looking radar imagery. By the eleventh and twelfth grades, students can begin to use large scale computer maps effectively. College students and in-house trainees (see fig. 2) can use more esoteric imagery such as ultraviolet and passive



Figure 1.— Fifth grade students surface-truthing aerial photographs and Landsat imagery.



Figure 2.— Landsat C workshop attendees using digitized map and imagery to prepare for surface-truthing field trip.

microwave radiometry, and the output of density slicers and other instruments. To iterate, the quality of learning is improved and the learning process speeded up at all of these levels by the early and frequent use of ground-truth field studies and problems.

DEVELOPMENT OF SURFACE TRUTH FIELD STUDIES

The development of surface-truth field studies involves the same basic stages and principles for all levels and types of instructional programs. There are four basic stages: Preparation, work in the field, post-trip laboratory, and evaluation of learning. These are discussed relatively briefly here to provide perspective on the operation as a whole, and in greater detail in the following chapters.

Preparation

Preparation includes choosing the window site or sites, gathering background information to supplement imagery data, preparation of learning kits, and pre-trip orientation.

Window site selection— It is almost always advantageous to select window sites elevated above the terrain to be studied, both to enlarge the visible horizon and to provide the student/trainee with a "semi-rooftop" view that not only clarifies some features and relationships that may not be as evident in an overhead view, but also provides a helpful transition to the vertical views of survey photography and satellite imagery. In flat terrain a rooftop or even upper story windows can help achieve this.

The field trip may include several window sites, or it may be restricted to only one site, especially at the lower grades or when the field site is at a considerable distance from the classroom/laboratory. Whether one or a series of sites are to be visited, travel time can be effectively used for identification and interpretation of features seen en route.

In planning a series of field trips, or a series of windows for a single trip, the most effective approach is to proceed from the well known, to the less well known, to the unknown (when the latter is feasible). Therefore, the campus or employment area provides an excellent starting point for the first window of the first trip. Whether located in the inner city or in a rural area (see figs. 3 and 4) a considerable variety of signatures and relationships will usually be visible at all scales of imagery. However, potential sites vary in their patterns and dominant land use, and in the internal variety of uses. Therefore, these elements should be considered in site selection. Use of multiple sites not only enables the introduction of a wider variety of signatures and relationships than does use of only one site; it also enables comparison of internal patterns, changes in the importance of a specified land use, and differences in rates of change in the several sites.

Elementary students become very excited and intrigued by correlating the location and identification of their school, home, and other points of personal interest visible in the field with their identification in the imagery and maps used (see fig. 5). Adults are less excited but no less interested in similar identifications. Because they are interested, their motivation to learn the principles, concepts, and elements of interpretation is increased. Therefore, mastery is more rapid and better retained as a tool for future application when it is based on the technology transfer of field



Figure 3.— POLIS site. Left: East from roof platform, shopping center parking building ("P" in fig. 15). Right: Southwest from ground platform, park north of shopping center.



Figure 4.— Rural/urban interface setting of Hort School, Bakersfield, California, fifth grade class, Velma Wallace, Teacher



Figure 5.— It is exciting to identify familiar places in imagery in the field, and helps develop spatial perspectives, seventh grade, Goleta Valley Junior High School, Goleta Valley, Merling Cummings, teacher.

recognition to imagery signature and map symbol identification, correlation, and interpretation, than when the learning process is based on classroom/laboratory work alone. This motivation, as well as the skills, carries over when previously unknown areas that cannot be visited for field study are investigated.

The multiscale factor of progression from field appearance to low-altitude photograph to satellite imagery will further enrich the field experience by expanding horizons and competence from local, to subregional, to regional, and multiregional scale. Finally, the field experience will clarify the comparison of the detail, area, and variety of phenomena that can be seen on the ground and in the several scales and resolutions of imagery and maps in the learning kit. Schwarz and Ellefsen discuss the criteria, process, and importance of site selection in chapter 4.

Gathering background information— Acquisition of background data will also vary according to the level and type of workshop, course, or training program. The elementary teacher may have already acquired sufficient knowledge of the window-site area to meet the needs of the students without further research. At higher levels of education and in-house training the instructor will

require more highly technical information. The sources of background information are as varied as the levels of education and training and the academic and applied disciplines that make use of remotely sensed data and maps. They include personal field investigations and interviews; statistical data; professional, popular, and government publications; supplemental maps; and models. While there is a minimum level of background information adequate to meet the needs of the program, there is no such thing as having too much information. Chapter 3 by MacKinnon and Wake discusses the acquisition of general background and site specific technical information and class trip planning.

The learning kit— Once the window site or sites have been selected, the learning kit may be developed. The learning kit discussed in chapter 5 by Stow, Estes, and Mertz cost nearly \$25 to assemble. The cost was met by assessment of \$15 per workshop registrant with a NASA Western Regional Applications Project contract supporting the remainder of the cost. While a similar kit is desirable, budget or other considerations may preclude its full replication. However, this need not, and should not, eliminate surface-truth field studies. Although the learning potential is sharply restricted, a single low altitude black and white photograph, a 1:24,000 scale topographic map, a road map, and supporting data (such as local maps, crop, soils, weather and climate, water, geologic, historical, and local plans) available free or at very low cost can constitute an effective and valuable learning kit when used properly. Therefore, a teacher who cannot completely replicate the learning kits (see appendix E) used in the Landsat C Workshop can still make effective and valuable use of surface-truth field studies and problems. Further, it is not absolutely necessary to provide each student/trainee with a complete set of imagery and maps. Indeed at the lower grades it is preferable not to do so because of the value of teamwork and sharing of data to speed up the learning processes by discussion and sharing of information, concept understanding, and problem solutions. Teams of three to a half dozen are usually the most effective, especially if they are permitted to be flexible by regrouping according to shifting points of interest.

Pretrip orientation— The pretrip orientation session includes introduction of the purpose of the field trip; the window sites to be visited; new signatures and map symbols, land uses, patterns, relationships, and applications to be investigated; review of signatures and relationships previously studied that will appear in the window sites to be visited; the sample reading, measurement, interpreting, updating, and other applications problems. Paper imagery and maps can be used effectively with opaque projectors to supplement ground platform, low-altitude oblique and other slides, and the learning kits in the student/trainees hands. The instructor or a friend might take the ground and low-altitude photographs, or older students might take them as an extra pretrip project. Field problem sheets, instruments to be used; the contents of the learning kits; logistics; timing; movement restrictions in the field; and appropriate dress for expectable weather complete the pretrip orientation. The use of cameras and binoculars should be encouraged.

Work in the Field

Work in the field may be divided into three periods. Upon arrival at the field site it is helpful to allow the students a few minutes to make random identifications by way of orienting themselves to the surface-truth process in the context of that site. With younger students it also helps to get them settled down so that organized work can begin more smoothly and effectively. The second period consists of identification of imagery signatures, relationships, and map symbols listed on the problem sheets. The third stage is the longest as it involves measurements of distances, directions,

and areas. The development of field problems and post-trip laboratory field-related problems are discussed in chapter 6 by Frasca.

Post-Trip Laboratory

The post-trip laboratory may be divided into two major segments. The first segment consists of recapitulation of the field work and discussion of the field problems. The second segment is then devoted to additional field-related problems. Questions may include comparisons and contrasts of the several sites visited with one another; with sites visited on earlier trips; and with sites, regions, and countries studied but not visited to expand the geographic and other educational and training value of the immediate surface truth field study.

Evaluation of Learning Achievements

Evaluation of learning achievements may be based on the problems worked in the field and in the post-trip laboratory, achievement may be evaluated by a separate examination, or the two methods may be combined.

Teaching/learning strategies appropriate to surface truth field studies for each level and type of instructional/training program from elementary education, through secondary education, to higher education, and government agency/industry in-house training programs are discussed by Hankins and Wake in chapter 7.

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Chapter 3

ACQUISITION OF BACKGROUND AND TECHNICAL INFORMATION AND CLASS TRIP PLANNING

Richard M. MacKinnon* and William H. Wake

INTRODUCTION

Instructors who have resided or worked in an area for several years will usually have considerable knowledge of the area and know several potential sample window sites. This knowledge will be invaluable in planning and conducting class surface-truth field trips, but it needs to be organized regionally and subregionally, systematically by topics, and by systems interactions. The process of organization will show additional factual knowledge needs and relationships that need clarification. The amount, nature, and technical depth of data needed will vary widely with the background and capability level of the class, the nature (general or specific topic) of the instructional program, and the characteristics of the window sites. The instructor must decide what information is needed for each site. For example, information on the coastal vegetation of the Santa Maria River Mouth area is important in the study of the Santa Maria Region, but has no significance in a study of the population and commercial characteristics of the POLIS site in Central Santa Maria some fifteen miles from the mouth of the river.

Instructors who are very familiar with the study area, as well as those who are not, will find the field-trip-information acquisition and planning process speeded and made more effective by organizing it in stages. The stages follow a deductive progression: from the associated context region, to the study area, to the specific sample window sites, and from generalized background information on the study region to specific technical data on the environmental and human use systems to be interpreted at each site. On the class trip and in the follow-up laboratory, the learning/interpretive process will first be deductive in applying previously learned information and skills to analysis of the study site, then inductive in reading and interpreting the landscape, imagery, and maps of the site, correlating them with information of other sample sites and building valid generalizations about the larger study area, its context region, and other (similar and/or contrasting) regions.

INFORMATION ACQUISITION STAGES

The first stage of information acquisition is, of course, to decide what kinds of information are needed, to organize and inventory present knowledge, and to consider sources of data. All three principal types of information sources (reading, field observation/analysis, and interviews) will be needed for any but very elementary knowledge of the area.

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It is axiomatic that the more information one takes into the field the more one sees and the more effectively one sees it. Therefore, the logical course is to read about the field area and study imagery and maps, then go into the field, and then interview specialists as the basis for further reading and field imagery and map analysis.

Because no area exists in a vacuum, but always in a series of larger spatial units, the reading will be most productive if it progresses from general to specific references interspersed with field work. Because remote-sensing data interpretation is basically a visual process of reading and interpreting field phenomena through imagery and maps, the stages of developing one's ability to see what is in the imagery are the same as the stages of developing one's ability to see what is in the field with the added element of learning to read, interpret, and correlate imagery signatures, map symbols, and field phenomena.

The process of data acquisition, window-site selections, and class-trip preparation may be staged as (1) general reconnaissance, tentative site identification, and preliminary planning; (2) site selection, detailed inspection/analysis, and final planning; and (3) class-trip preparation. The stages may be divided into prefield, field, and post-field phases. Like the information requirements, the time required will vary according to the instructor's information base, the level and nature of the instructional course, and the environmental/use complexity of the study area. One day might suffice for an elementary teacher to adequately complete the entire process for a campus-centered site.⁵

Instructors may vary sequences and eliminate some steps as unnecessary or infeasible. They will best know their needs, capabilities, and constraints on their time.

GENERAL RECONNAISSANCE, TENTATIVE SITE IDENTIFICATION, AND PRELIMINARY PLANNING

Purpose

The purposes of this stage are to:

- Acquire or enhance general knowledge of the study area characteristics and its external and internal relationships.
- Identify potential window sites.
- Establish local contacts for interviews and acquisition of technical information.
- Make preliminary plans and logistical arrangements.

⁵The reading, field work, laboratory preparation, planning discussions, and learning kit assembly for the Landsat C workshop averaged approximately two work-weeks for each of the six geographers involved in developing the workshop field/laboratory element plus staff assistant time, although most of the logistical arrangements were made by Garth A. Hull, NASA, Workshop Co-chairman, and Richard M. MacKinnon, local geographer.

Activity phases—

1. Prior to the reconnaissance trip. Background reading of regionally organized, national scale references will provide a sound base of understanding of the study area as a whole and its relationships with other areas. Sample references and sources for each stage are listed at the end of this chapter and in the selected bibliography in appendix F. Systematic references will amplify and clarify discussions and terminology in the regional studies. To enlarge the scale of information, commercially published state-level regional studies may be consulted along with Federal and State Agency maps and other publications. These agencies have offices in all major, and many smaller cities and are listed in the telephone directory, though sometimes under two or three different headings. College/university and public libraries and geography departments will also have lists of available publications if not the actual publications including maps, or will be able to assist in locating and acquiring them.

Development of a preliminary statement of purposes, goals, and objectives for the class trip and by site, by topic helps to refine and direct one's thinking, however sketchily the statement is written. The instructor should expect to revise and expand it with additional site differentiation as knowledge is acquired.

Small (satellite) and medium scale (U-2) imagery of the study area should be obtained as early as possible along with topographic maps at 1:250,000 and 1:24,000 scales, and geologic and road maps (see appendix F).

After reading and examining imagery and maps, the reconnaissance trip may be planned effectively. If possible it is very helpful to enlist the aid of a knowledgeable local resident who is free to assist in planning the route, locating information sources, arranging interviews, and, most important, provide background information, accompany the instructor on preparatory field trips, suggest window sites, and help to establish local logistical arrangements if any are needed. If the instructor does not know such a person, the local or nearest chamber of commerce office can usually provide considerable assistance in identifying information sources and arranging logistics as well as in providing local maps and other publications. Personnel in environment-related government agencies (see pp. 25-27) in the instructor's community are also helpful in identifying their counterparts in the study area.

The date of the class trip should be set and transportation arrangements made as early as possible along with obtaining administrative clearance and parental consents when needed.

2. In the field. If it has not been possible to develop local contacts prior to the field reconnaissance it is helpful to make the local, or nearest, chamber of commerce the first stop on the trip. The personnel are usually well acquainted with persons in government agencies and key persons in study area industries, know local meal and lodging facilities, and can provide local maps and other informational publications. Local newspapers and museums often are excellent sources of information about the study area. If it can be arranged, even a brief aerial reconnaissance, with imagery and maps in hand, is very helpful. With this information the ground reconnaissance itinerary can be finalized to maximize time-efficiency and provide reasonable assurance that all major centers, subregions, and activities of the study area will be included along with stops for preliminary interviews and acquisition of large scale low-altitude photography, map, and other technical publications. If the study area does not include the county seat, a separate trip to it may be necessary to obtain

government agency publications as was the case with Santa Maria which is in Santa Barbara County. Low-altitude photography also was available only in Santa Barbara.

The route plan will depend upon the size and general layout of the study area. In a small area with a single small community a transect along the major arterial, another across its center, and a circuit near the study-area perimeter may suffice. In another area, it may be preferable to set up a serpentine pattern and circuit. In a large metropolitan area it may be best to start from the center of the major community and proceed to a sequence of selected subcenters. Alternatively it may be best to avoid the Central Business District (CBD) and major community core and select a relatively compact group of sample site areas near and at the metropolitan fringe.

In planning the route, it should be kept in mind that the window sites should be selected to provide representative samples of the study-area characteristics as a whole, as well as provide samples of environmental and land use types. The purpose of this consideration is to enable student/trainees to build valid generalizations about the larger associated study area from the sample evidence at the window sites. Each site will provide a sample of one or a limited range of land use/land cover examples of regional pattern characteristics and relationships if it is selected properly. The set of sample sites will provide the foundation for development of the characteristics and relationships of the study area and region. Almost every potential sample site will have one or more anomalies in it, like the oil refinery and urban encroachment at the Ceres site which was selected primarily as a sample agricultural and grazing area. Such anomalies can be helpful in eliminating the need for additional windows, but need to be noted and explained. Plotting potential sample site areas on a map is the best first step in planning the route to ensure adequate sampling and facilitate comparison of possible sites. One should keep in mind that in the prefield phase, possible *areas*, not specific sites are being plotted. Only by viewing specific potential sites on the ground while studying them in imagery and maps can decisions be made on the basis of field visibility, variety of signatures, and other criteria discussed in chapter 3. Notes should be kept on each site as well as plotting it accurately on the imagery and maps for later comparison and selection decisions. If meals and/or lodgings will be needed, preliminary arrangements are best made on the reconnaissance trip.

3. Post-field activities. After the reconnaissance trip, the instructor will want to read newly acquired materials, review imagery and maps, and finalize site selections. Then specific low-altitude photographs can be ordered that center at or near the sample sites and, if work with stereo-pairs can be included, have the desired overlap and/or sidelap. A tentative class-trip log and set of field and laboratory problems can now be developed.

SITE SELECTION, DETAILED INSPECTION/ANALYSIS, AND FINAL PLANNING

Purpose

The purposes of this stage are to:

- Confirm final site selections (occasionally one will discover reasons for changing sample sites even at this stage); inspect/analyze each site in detail; note characteristics, patterns,

anomalies, and relationships and correlate field appearance with imagery signatures and map symbols.

- Acquire additional general and technical information one has become aware of.
- Field test and revise the tentative field/laboratory problems.
- Finalize class trip route and timing, and field test and revise the trip log and plan.
- Finalize logistics.

Activity phases—

1. Prior to the field trip. The class-trip plan and field log can usually be developed only in rather broad form prior to the instructor's site selection trip. It should begin at the initial point of departure and include questions/problems on the entire trip with points and developments of general interest and contrast with the study area, as well as those resembling study-area sample-site characteristics. These questions/problems will not only make the enroute time more interesting to the students but will provide excellent learning/skills development of landscape-imagery-map reading/interpreting experience, and spatial comparison/contrast, and will clarify the characteristics of transition from one area to another. Point-to-point distances and approximate running time notations in the log will facilitate location and orientation.

Appointments should be made as needed for further interviews or arrangements. Then the trip itinerary can be planned.

2. In the field. Local contact persons may be visited to discuss sites selected and plans for the class trip. Some revisions may result which will improve the learning quality of the trip, and insights will always be sharpened.

The itinerary should include a visit to each site and plotting of the route details between sites as well as to and from the home area. Field accessibility, restrictions on movements at sites, parking places, and refreshment breaks should be noted in the trip log as well as a description of field visibility. At each site and en route between sites, the tentative field/laboratory questions and problems, and the route and timing may be finalized.

Local logistical arrangements also may be finalized, including estimated times of arrival at meal and/or lodging accommodations, and noted in the trip log.

3. After the trip. Imagery, map, published and field note information should be reviewed and organized, and incorporated into the class trip plan. Detailed plans for the use of each sample site can be finalized. The trip log can now be put into final form, and the class orientation sessions planned. Multiple copies of any materials not already obtained should be acquired or duplicated for class distribution.

CLASS-TRIP PREPARATION

Purpose

The purposes of this stage are to:

- Ensure a logistically smooth trip.
- Finalize preparations to maximize the learning/training value of the trip.

Activity phases—

1. Prior to the class trip. Final technical details should be obtained and incorporated in plans for the trip as a whole and for each sample window site.

The trip log and plan, and list of items each student/trainee needs to bring should be duplicated and assembled with the learning kit discussed in chapter 5. Actual distribution may be made in advance of the orientation session, or may be delayed until the orientation session, especially for younger students — the timing is an instructor's decision.

A display of student/trainee learning kit and other imagery, maps, and publications may be set up in advance of the orientation session, especially for younger students, to build general familiarity with the area to be visited and the purposes of the class trip. Finally, the orientation sessions should be held as close to the date of the class trip as feasible unless the instructor has included a pretrip library research unit, in which case two orientation sessions may be needed.

2. In the field. The instructor may wish to make a final personal visit to the sites before the class trip, or may consider it superfluous.

The class trip itself is discussed in other chapters. Teaching/learning principles which may be used are discussed in chapter 7.

3. Post-field activities. These consist of the recapitulation discussion and laboratory outlined in chapters 2 and 6.

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National Scale Regional References

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Economic Geography and Conservation References

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- Haggett, P., *Geography a Modern Synthesis*, Harper & Row, publishers (2nd edition), 1972 (with Instructor's Guide and Student Manual).
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Federal Agency Sources of Useful Maps and Publications

- U.S. Bureau of the Census
- U.S. Bureau of Land Management
- U.S. Bureau of Reclamation
- U.S. Department of Agriculture
- U.S. Department of Commerce
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. Geological Survey (see Appendix F), also Geography Program LUDA Project Maps: "Land Use/Land Cover," Political Units, County Census Subdivisions," "Hydrologic Divisions," Scale 1:250,000.
- U.S. National Aeronautics and Space Administration (see Appendix F)
- U.S. National Park Service
- U.S. Soil Conservation Service, example: "Soil Survey of Northern Santa Barbara Area, California"

California State Agencies as Examples
(Agency names will vary from state to state)

Air Pollution Control Board

California Department of Transportation

Department of Conservation

Department of Finance (Population Data)

Department of Food and Agriculture

Department of Forestry

Division of Mines and Geology (source of geologic maps, scale 1:250,000 and other maps and publications)

Department of Natural Resources

Department of Parks and Recreation

Department of Water Resources

Environmental Data Center of the Office of Planning and Research

Water Quality Control Board

County Agencies of Santa Barbara County and Publications as Examples
(Agency designations, functions, and available publications will vary widely from state to state
and from county to county within states)

Santa Barbara County Agricultural Commissioner, "1976 Crop Report"

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Santa Maria Land Use Maps, Scale 1:7,680

In some counties, Public Works Departments and County Water Agencies can provide much helpful information.

City Agencies such as Planning Departments can also often provide useful materials.

Popular travel-oriented periodicals, travel agents and automobile clubs also often are sources of useful background information.

Chapter 4

FIELD SITE SELECTION

David E. Schwarz* and Richard E. Ellefsen**

INTRODUCTION

For over a decade it has been naively assumed that remote sensing has eliminated the need for field work in the education and training of remotely sensed data interpreters. The modern concept of data gathering through remote sensing embraces the notion of "multistage sampling" – the gathering of information from several elevational vantage points. Usually these are thought of as satellite, aircraft, and ground sampling, though there are many variations. Surface or ground truth is also necessary for accurate mapping of the complex earth surface. Certain phenomena, for example the distinction of some small grain crops, may often initially be differentiated only through very close field observation. Once a sufficient sampling of fields of a particular crop type has been identified with certainty on the ground, aerial photography can be scanned to determine if that crop exhibits a consistent appearance, or "signature." If it does, then no more field work is required to map that particular crop for that place and time. However, if the crop signature shows inconsistencies, it might be necessary to assume that the crop can be confidently identified and mapped only through field work.

Similarly, sampling of phenomena with consistent signatures in aerial photographs can be compared to satellite images which have greater aerial scope but poorer resolution, to determine whether mapping can be expedited through the use of satellite imagery. This is the basic concept of multistage sampling.

Mapping through remote sensing has not obviated field work, but integrates it with remotely sensed data so that each level of data gathering is used with efficiency which contributes to the importance of careful selection of instructional field sites.

IMPORTANCE OF SITE SELECTION

The selection of window sites for valuable field learning is important because only through observing spatial phenomena in the field setting can the advantages and shortcomings of the various remote sensing devices be effectively conveyed to the student. The colors and tones of images viewed in the laboratory are thereby given real meaning: for example, the mottled appearance of a corn field on an air photo is shown to truly represent differences in crop vigor due to drainage variations; the bright spot on a radar image is seen to be due to the angular, metallic, close-packed structures of a mobile home park; and the difficulty of classifying a pixel of Landsat data can be

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related to the diversity of landscape elements encompassed in a one acre patch of residential neighborhood. Scores of such examples train the interpreter to understand the true meaning of signature and resolution and force him to think of the way the landscape is assembled and how well each sensor functions to sort out its components.

RATIONALE FOR FIELD SITE SELECTION AS A TEACHING EXERCISE

Several general guidelines should be kept in mind when considering the selection of field sites for teaching remote-sensing fundamentals. Proximity and vantage point are two very practical considerations. It is impractical to select sites which are widely spread or far from the central class area. Likewise, it is senseless to take a group to a field site where no viewpoint is available to afford sufficient scope for demonstrating the importance of the site. Only through viewing a broad enough area to place the site in context can one make efficient use of a site. Consider also the effects of inclement weather when selecting sites; try to imagine what the condition of the vantage point would be during or after a storm.

Criteria for Site Selection

The following criteria for site selection are equally critical if the field work is to be an effective tool to illustrate remote-sensing principles. It is interesting to note that the sites themselves can be best selected only through a combination of image interpretation and field reconnaissance.

- *Represent the range of class interest.* A general introduction to remote sensing will require as wide a range of physical and cultural landscapes as can possibly be encompassed in a reasonable number of sites. These would probably include an overview of the geologic and geomorphic structure of the area, hydrology, soils, and land covers and land uses ranging from natural and cultured vegetation classes to urban land use types. If, however, the class has an educational focus such as urban planning, it would be senseless to give extended attention to less relevant topics such as agricultural patterns.

- *Each site should have a theme or add something no other site offers.* Though there will be redundancy in what the sites illustrate, each should offer differing insights into the mapping applications of remote sensing. It is difficult to visit many sites in a small time, which requires that each be used efficiently. This can be done by selecting each site for a particular theme which may vary from observation of a variety of regionally representative crop signatures to the illustration of the conversion of land use from agricultural to urban use. Specific illustrations of sample site themes will be given later in the discussion of the Landsat-C Workshop.

- *Strive for intrasite variation within the theme.* Again, since the number of sites visited will be few, it is important to encompass as much variety as possible within each without disrupting the overall unity of theme. For example, an agricultural site should show as great a variety of crops and agricultural techniques as possible. The students will encounter a great number of varying spectral signatures during image interpretation, so as many phenomena as possible should be observed in the field.

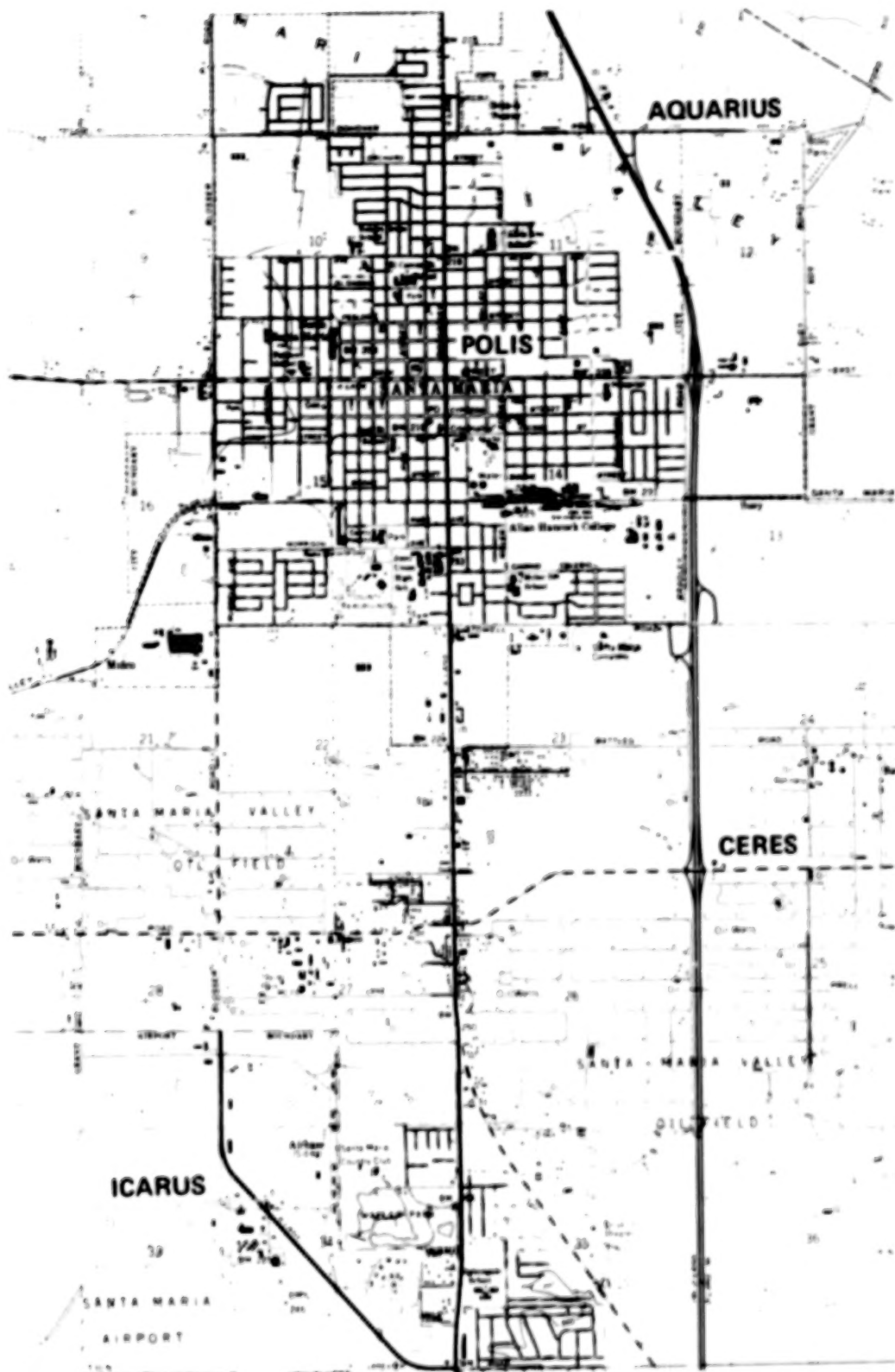


Figure 6.— A portion of the Santa Maria quad provided at reduced scale of 1:48,000 showing the locations of the four field observation sites.

- *Illustrate ground resolution and spectral signature distinction.* It is assumed that the student will view imagery of several types and of varying ground resolutions. The field instructor should illustrate the size of a Landsat pixel (picture element) at one or all sites and should indicate which and how many landscape elements can potentially fall into that size resolution cell. A similar feeling for the spatial averaging done by each sensor can best be gained in the field.

It is good to point out in the field that some phenomena are not easily separable, even when viewed from only a few hundred meters distance on the ground, while others readily contrast with adjacent land uses. Grasses of all types, including both improved pasture and natural grassland, often appear spectrally similar though they are conceptually distinct entities to the user. This implies greater problems for separating the uses through remote sensing.

- *Do not order the sites sequentially.* It is best not to assume that the students will visit the sites in any sequence. Small groups are best in the field, and if it is necessary to divide into subgroups, each may visit the sites in a different order. Though not critical, sequential numbering may also imply a ranking of importance where none is intended.

When well done, field work is a most effective device for demonstrating remote-sensing principles and applications. The student needs to be prepared for the field exercise through classroom introduction to the basics of remote sensing, but the careful selection and use of field sites is equally important.

SITE SELECTION FOR THE LANDSAT-C WORKSHOP AT SANTA MARIA

Four field sites were selected for study at the Santa Maria workshop (see fig. 6). No site was more than three miles from workshop headquarters. More than 300 participants visited the sites within about 2 hr. (The schedule had allocated 1 hr for each site but had to be halved because of rain during the morning portion. See appendix A.) Accommodation of such a large number was made possible by dividing into four groups, with each group beginning its circuit at a different site with several faculty members and student assistants in each bus. Still, the sections were larger than desirable for effective field observation, but the great interest in the Landsat-C workshop made large groups necessary in both the field and laboratory sections. Parking space was readily available for the buses at each site. Had the field exercise been scheduled for other than a weekend, a problem might have been encountered at the central city site.

Good, usually elevated, positions were available at each site to allow ready viewing. A large observation deck was used at the airport, and the rooftop of a large parking lot and a small park were both available at the urban site. Modest elevation above the generally flat valley floor was provided at the other two sites by a levee along the Santa Maria River and by the retaining wall of a pond and the edge of a marine terrace in the agricultural area.

Site Names and Themes

Attaching classical names to the sites followed a NASA tradition, avoided ranking the sites, and implied a readily identifiable theme or location for each. Thus, POLIS was clearly identified

with urban matters; CERES was associated with agricultural; AQUARIUS was located at the river; and ICARUS was the airport site. A wide range of land uses and covers was observed and discussed from these four points and en route between them; travel time was not omitted from the learning process.

The CERES site provided the best overview of the valley. The geomorphic history of the area could be read from the landscape there. Immediately at hand were a variety of crops as well as the Santa Maria oilfield and the beginning of urban fringe industry expansion. Thus, though the emphasis was on the agriculture close at hand, it could clearly be seen that the production of oil and urban expansion provided two more inseparable veneers of land use, and all three could be viewed in the perspective of the physical structure of the region.

Change detection was the theme of the AQUARIUS site. New subdivisions and a mobile-home park abutted cropland to mark the encroachment of residential uses on agricultural land. By viewing a four-year-old air photo from the learning kit and comparing it with the view of the rolling hills to the north of the river, the participants could sketch a map indicating changes from extensive pasturing to the planting of citrus orchards and vineyards.

Not all changes at the AQUARIUS site occurred so slowly. Heavy rains immediately preceding the workshop dates washed out the ford, and the normally dry riverbed was bankfull. Careful viewing of large scale photography of the area correlated with field observations enabled the detection of other environmental damage.

Urban land use and plotting of the temporal change of land use at a larger scale were the emphases at the POLIS site. A dramatic restructuring of downtown Santa Maria had recently been completed. The overall urban geography as well as urban land use change were studied and mapped in the field. The tightly packed, small parcels of land characteristic of urban areas necessitated a larger mapping scale and also implied that finer resolution of remotely sensed data would probably be necessary to accurately map detailed land use.

The airport site, ICARUS dealt primarily with the signature concept. An industrial park, a woodland, and a city park provided examples of common land use and cover classes not seen in the other three areas. The students were also asked to consider the appearance of a Landsat pixel astraddle the airport runway and the grass surrounding it. Questions about the classification of such a picture element were explored, especially assuming automated classification based on simple reflectance values.

The four Santa Maria sites attempted to satisfy the criteria outlined. They were close together and provided good views of broad areas. They illustrated the diversity of the area with emphasis on land-use/land-cover mapping. Each site had its own emphasis, but also provided internal variety. A broad range of spectral signatures representative of the area was viewed in the field to be recalled during image analyses in the laboratory sessions. Finally, a feel for the landscape complexity was afforded, with some suggestions as to the appropriate remote sensing techniques for capturing that complexity.

Chapter 5

CREATION OF LEARNING KITS

Douglas A. Stow,* John E. Estes,** and Frederick C. Mertz*

INTRODUCTION

A learning kit is an essential part of any remote-sensing workshop, course, or in-house training program to provide the "hands-on" experience of working with remotely sensed imagery. This is the objective of laboratory and field exercises as well as the reason behind the production of imagery/map kits. The way in which these learning kits (containing conventional remotely sensed and collateral data products) were put together is the focus of this chapter.

Working within the framework of a workshop, course, or training program involved in introducing remote-sensing technology, there are a variety of concerns that will influence the creation of learning kits. Some of these are: Budgetary constraints, number of imagery types, and number of collateral data types.

In the following sections we will look at each of these three main concerns individually, with respect to the way they influence the production of the kits.

BUDGETARY CONSTRAINTS

Ultimately, the scope and quality of the contents of the imagery/map kit are a function of the funds that are available for their creation. Monetary constraints then obviously influence all decisions concerning the preparation of the kits.

Whether production costs are supported by an institutional grant (e.g., government, NCGE, school, company) workshop enrollment fees, departmental budget, or a combination of sources, sufficient funds must initially be set aside or made available for learning kit development. In order to determine what a "sufficient" funding level might be, a carefully thought out assessment of total available funds, projected expenses for kit development, and other expected costs should first be considered.

It is suggested that a major portion of available funds be allocated towards the development of the kits. A major part of the ultimate value of the kits is the fact that they can be reused to further education and the transfer of remote-sensing technology to a wider audience than is possible with just one use. If large quantities of image and collateral data are produced at once, the cost per kit

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can be lowered significantly. This is basically the idea of economy of scale — the greater the quantity of each item you purchase the less the cost per item.

NUMBER OF IMAGERY TYPES

With the wide variety of remotely sensed types of imagery available, decisions must be made as to the types and formats of imagery that are to be included in the learning kits. Factors such as the availability of existing imagery, which imagery will be the most often utilized by the participants, the cost of new image acquisition, and the reproduction of image products must all be considered.

Therefore, a prime consideration in the selection of imagery examples should be products that are most commonly used and available. Standard products such as: (1) low-altitude, vertical aerial photography (black and white, color, or color IR); (2) NASA/U-2 high-altitude, false-color vertical photography; and (3) Landsat/Multispectral scanner images (black and white color composite) best fit these characteristics of common usage and availability.

It was found that standard vertical 1:20,000 scale color photography (figs. 12, p. 47; 13, p. 49; 14, p. 51; 15, p. 53) is readily available from local aerial survey firms at a reasonable cost. Such firms typically have coverage of most areas in close proximity to their own location. By contracting a firm with which you have had previous dealings it may be possible to have photographs reproduced at a cost that is close to that of the firm's production costs. Such would especially be true when an aerial survey firm realized that the imagery is being used for a one-time educational experience that is sponsored without profit motives and, significantly, whose students might represent potential clients.

High-altitude, false-color infrared imagery is readily obtainable directly from the EROS Data Center, Sioux Falls, South Dakota, or from the USGS National Cartographic Information Centers, and indirectly from a variety of user institutions and commercial distributors. Positive prints (see fig. 7) may be reproduced in the same manner and at a similar expense as the low altitude photography, after an initial expensive processing procedure. The color transparency form in which most high-altitude imagery is available must be first converted to an internegative, which is then used to produce positive prints. Creating the internegative is somewhat expensive and is an operation which many commercial photographic firms may not be capable of handling. Thus a local airphoto firm or an appropriate photographic processing firm which can handle this task must be located.

Including examples of Landsat/Multispectral signature imagery in the learning kits may be warranted, depending on the goal of the particular course, workshop, or training program. Considering the attention Landsat data are getting in remote-sensing research and technology transfer activities and the impact the synoptic satellite perspective can add, we highly recommend the addition of Landsat scenes of the study area. It may not be necessary, however, to supply high quality positive prints or film transparencies as they may be too expensive to justify with respect to their limited usage in the laboratory and field exercises. A method of fairly inexpensive reproduction of an existing Landsat color composite is to use a color Xerox Machine reproduction (see fig. 8). A color Xerox of the Landsat scene containing the study areas allows the student to become familiar with the characteristics of Landsat imagery, at a great savings in reproduction costs, and broadens perspectives to regional scale.





Figure 7.— Portion of a U-2 high altitude flight (60,000–65,000 ft), CIR print, Santa Maria Area, scale of 9" x 9" image provided approximately 1:125,000.

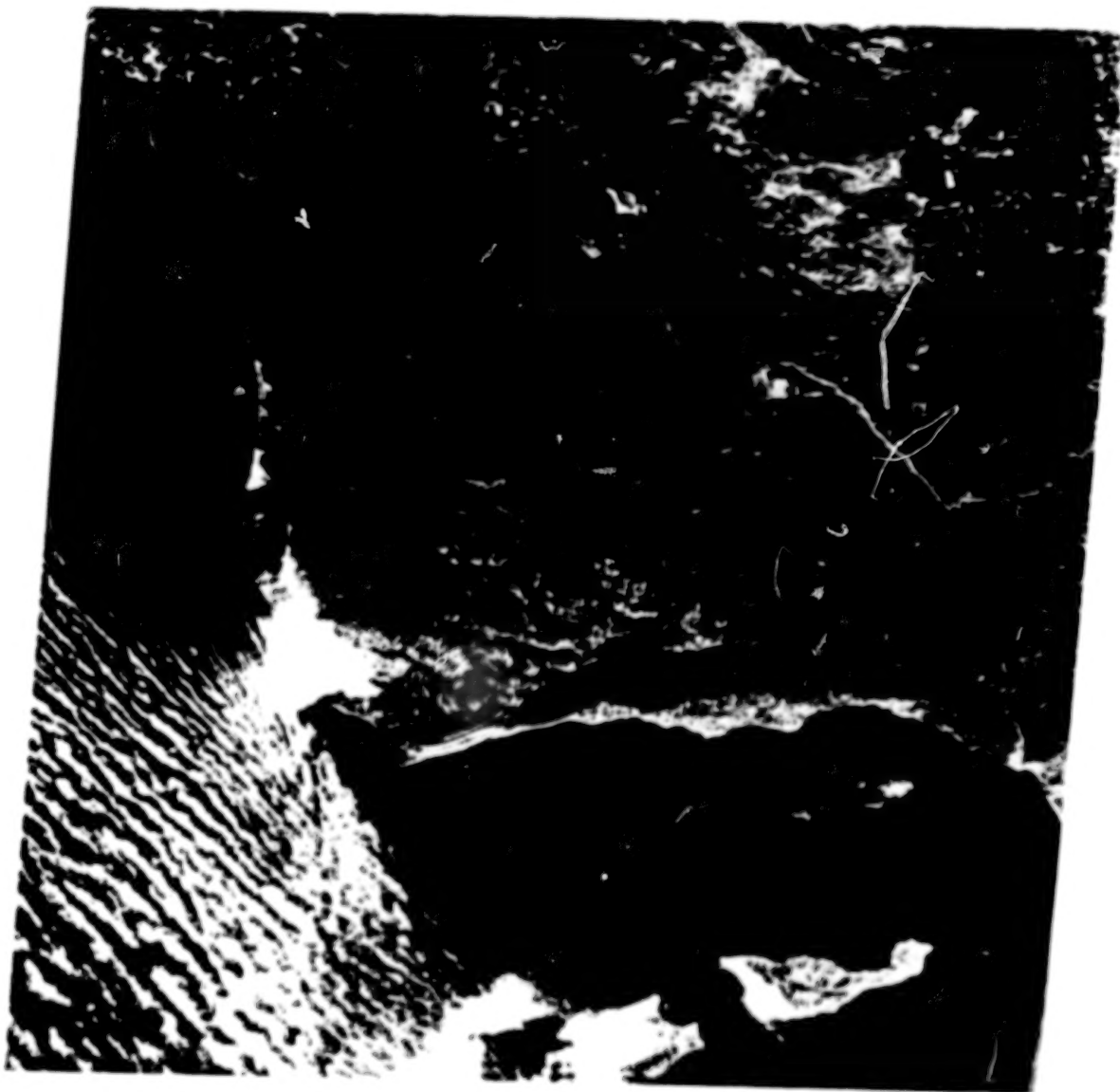


Figure 8.— Portion of Landsat CIR print, Santa Maria Area, 9" x 9" image provided at approximately 1:1,000,000 scale.

The image examples mentioned thus far may be considered conventional types that can be successfully used as aids in remote-sensing laboratory/field exercises. Other imagery types may or may not be deemed appropriate for inclusion in learning kits depending on the scope of the workshop, course, or training program, and again, on available funds. Examples of other imagery types include oblique photography, panoramic photography, thermal infrared scanner images, passive microwave imagers and active microwave (side looking airborne radar) images. If not appropriate for actual laboratory/field exercise usage, some of these image types may be included as 35 mm slides which are much less expensive to reproduce. The decision to include nonconventional image types must depend on whether or not it is already available; where, with the exception of oblique photography, new data acquisition would be unjustifiably expensive.

One final consideration in the choice of imagery types is the aerial coverage or scale of the imagery to be included. This depends heavily on the number and location of the field sites. That is, if there are many well-dispersed field sites it may be necessary to include many low-altitude photographs that will contain those sites. Ideally, imagery of at least two or three scales will be included. One U-2 photograph and one Landsat image will usually cover all of the field sites, and provide the desired second and third scales of imagery.

NUMBER OF COLLATERAL DATA TYPES

To enhance both the demonstration of utility of remotely sensed data and the effectiveness of laboratory/field exercises, it is useful to include collateral (nonremote sensing) types of data. The inclusion of topographic and thematic maps of varying scales has primary value (especially for geographers). The symbolism and portrayal of physical and cultural features on maps are an excellent supplement to imagery for the novice interpreter learning to work with remotely sensed imagery of the objects and phenomena of the natural environment and its uses.

Existing coverage of map data tends to be much more available and less expensive than imagery coverage. Standard map products are distributed by a variety of agencies, (USGS, local governments, chambers of commerce, and commercial distributors); some may even be available in quantity. Map products found to be useful as inclusions in workshop kits are:

- Landsat/MSS derived land use/land cover maps (see fig. 9)

- 1:24,000-scale and 1:250,000-scale USGS topographic maps

- Soils and Geologic maps

- Local large-scale chamber of commerce or gasoline company road map of the study area

Landsat/MSS (Multispectral scanner) derived land use/land cover maps are potentially the most expensive and time-consuming product to develop, yet are a valuable tool for demonstrating the practical applications of remote sensing data. A final product map may be reproduced on a transparent medium which has a scale that exactly overlays a standard topographic map (see fig. 10). If such a land use/land cover map has been previously generated and can be acquired, the overlays can be produced at only the cost of reproduction thereby avoiding expensive computer processing and, potentially, the acquisition of a Landsat Computer Compiled Transparency (CCT).

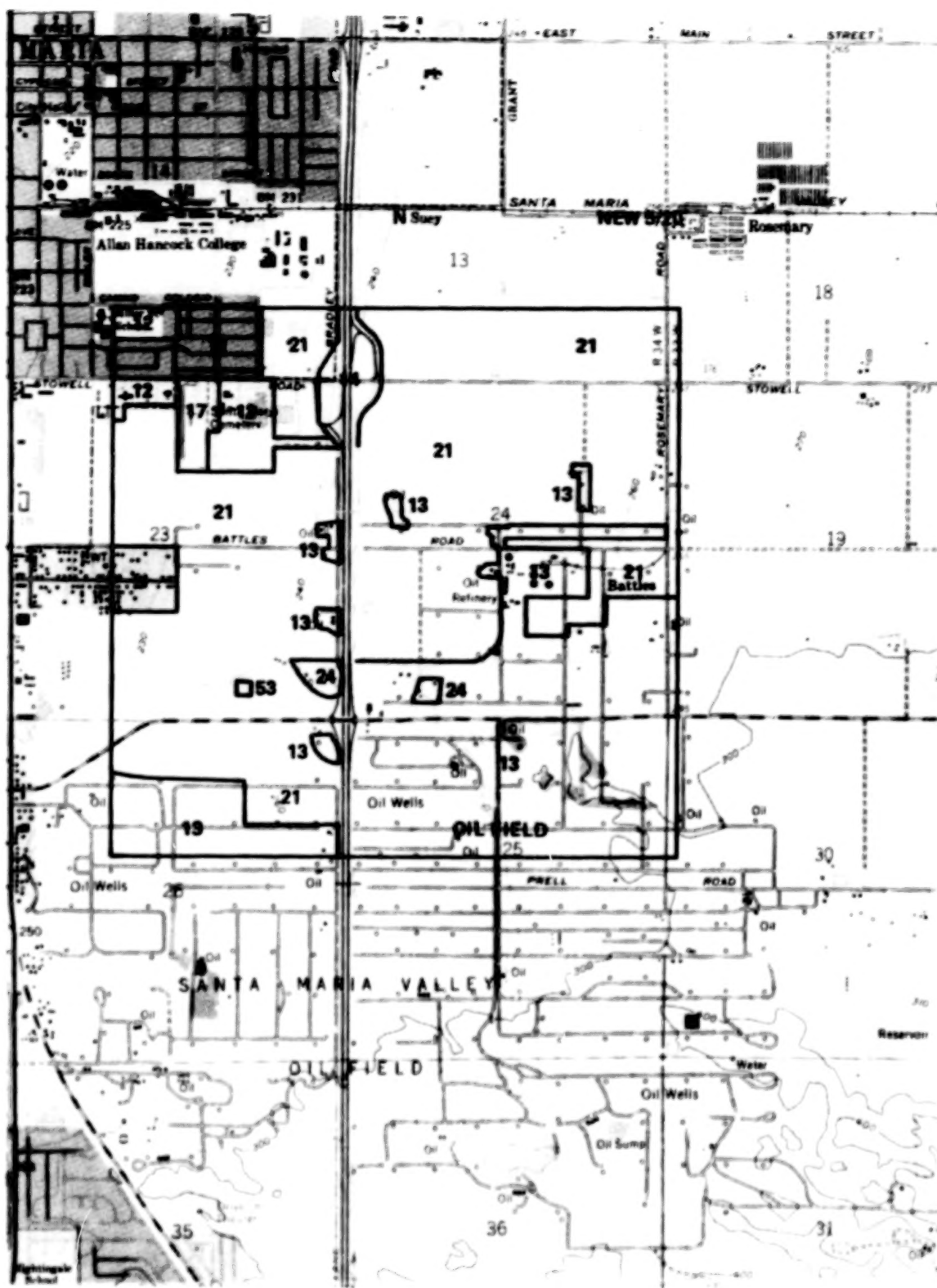


Figure 9.- CERES site portion of USGS Geography Program Land Use/Land Cover Map, level 2 classification, 1:24,000 scale. See pages 48 and 50 for the complete level 2 classification system.

Existing map products (topographic, soils, local, etc.) can be acquired in bulk quantities at low costs, which usually include a considerable discount. 1:24,000 and 1:250,000 scale topographic and land use maps are available in large quantities from the USGS in Denver, Colorado. Soils maps may be obtained from the Soil Conservation Service. Local street and commercial maps are available from chambers of commerce, local governments, gasoline companies or commercial distributors. It should be noted again that many of these collateral data products may be obtained at minimal to no cost when they are requested as donations toward the advancement of education.

A simple grid planimeter (see fig. 11) was provided to enable the approximate measurement of areas. Participants were asked to bring magnifying glasses, rulers, and protractors to measure distances and directions.

Two very helpful learning kit items were contributed by user agencies. Eugene C. Napier and the staff of the USGS Geography Program Western Region Mapping Office, Menlo Park, California, compiled and distributed a 1:24,000 Level 2 Land Use/Land Cover Classification map of Santa Maria based on U-2 imagery. James R. Wardlow, Senior Land and Water Analyst, Division of Planning, State Department of Water Resources, Sacramento arranged the contribution of the DWR 1:24,000 Santa Maria Land-Use Map (reduced to 1:62,500) based on low-altitude photography. Our thanks to them and to their agencies.

Final additions to the remote-sensing learning kits are the literature describing the principal sources and potential uses of remote-sensing data. Although these topics are the subjects of discussion in the course, training program, or workshop sessions, it is important that the participants be able to take home some printed information concerning sources. Such information is available in the form of NASA and USGS/EROS pamphlets, as well as in remote sensing texts such as *Everyone's Space Handbook*, Kroeck, 1976, which also was included in the Landsat C Educational Workshop Learning Materials Kit.



Figure 11.— Graphic planimeter, scale 1:24,000 in metric units on USGS Topographic Map, Santa Maria. Top left: 1 km² (km²:1 hectare (ha)); top right: 1/2 ha; bottom right: 1/4 ha; bottom left: 100 ares (ar). CARTREMS Laboratory, San Jose State University.

Chapter 6

LANDSAT C WORKSHOP FIELD/LABORATORY EXERCISES

J. W. Frasca*

INTRODUCTION

The increasing use of remotely sensed materials in problem solving is indicative of growing acceptance of them as effective tools for spatial analysis. It has been suggested by at least one geographer that any new research tool undergoes several stages of development before it is finally accepted as a legitimate technique by the scientific community. Growing professional acceptance is evident by a trend of increasing "... use of remote sensing as a tool in problem solving wherein the problem not the technique is emphasized ..." (Higgs, 1976, 95).

The importance of surface-truth field instruction in the process of achieving the learning and technique mastery that enables the use of remote sensing as a problem solving tool has already been discussed. The inclusion of specific field, and field-related, problems forms a major contribution to the value of the surface-truth field study learning process.

The difficulty and complexity of problems, like all phases of the learning process, need to be tailored to the capability level of the learners, and the location, nature, scope, purpose, and duration of the instructional training program. However, the principles of meaningful instructional problem development are universal.

The problems are valuable because they focus the learner's thoughts on a sampling of real world information needs that parallel the kinds of needs found in many other parts of the world and provide practical experience in answering the questions asked and solving real world needs. Their value is maximized by including questions of object identification, patterns, relationships, and (when possible in the available field study areas) disaster assessment in multitemporal and multi-spatial frameworks that often involve the use of several types of imagery and supportive data.

Once it has been determined that remotely sensed materials can be beneficial in spatial problem solving, decisions must be made as to the most appropriate materials to use in the investigation. For example, the solution of a problem may require the use of a computer processed digital Landsat image augmented by a U-2 false-color infrared (CIR) photograph. An equally important decision must also be made regarding sensor product scale; inappropriate scale selection could minimize or eliminate important extractable information from the image. For example, regional timber inventory and resource analysis might require small scale coverage such as visual and digital processed Landsat imagery supplemented with high altitude U-2 photography whereas a micro study would require large scale low altitude photographic products.

Collection of ground information and supportive materials are absolutely necessary to verify and substantiate data extracted by the interpretation process regardless of sensor type and scale.

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Field observation and notes, the use of topographic and thematic maps, crop calendars, and climate records are just four examples of supportive materials which often are used in conjunction with remotely sensed materials. Illustration of this integrated multisensor approach is provided by four examples from the March, 1978 Santa Maria Landsat C Conference and Workshop. Four distinctive window sites were selected to demonstrate the usefulness of remotely sensed materials to solve geographic problems.

ICARUS

The ICARUS site (see fig. 12) was characterized by the Santa Maria airport facility plus a variety of land-use types including recreational facilities, industrial and commercial establishments, residential structures, utilities, and transportation facilities. The field and laboratory problems for ICARUS required the investigator to develop basic interpretation clues by identification of these features. Interpretation of objects within ICARUS required the use of multisensor and multiscale imagery (low-altitude color verticals and high-altitude U-2 color infrared) plus use of the digital Landsat land use classification map. At the airport facility a pixel (picture elements, 57 X 79 meters) was delineated in order that workshop participants might better understand the basic collection unit and resolution cell of the Landsat MSS sensor. The use of these materials at ICARUS introduced the workshop participants to the human, machine, and combined approach to the interpretation of remotely sensed imagery.

ICARUS Field/Laboratory Problems

Whether through a human, machine, or combined approach to the interpretation of remotely sensed imagery, resultant interpretations are based on one or a combination of the following elements:

- | | | |
|-----------|---------------|----------------|
| 1. Size | 4. Texture | 7. Site |
| 2. Shape | 5. Tone/Color | 8. Association |
| 3. Shadow | 6. Pattern | 9. Resolution |

Using the copy of the Landsat classification scene, U-2 high altitude false color IR image, and low altitude air photos of the ICARUS and CERES sites, answer the following:

1. a. On print PW-SM2-32 (fig. 13) identify the features surrounding letters G and K, and the feature north of the MOBILE HOME PARK due east of the airport loading facility.
b. On print PW-SM2-23 (fig. 12) identify the features in the vicinity of letters C, S and H.
c. All identifications should be supported with discussion of the major interpretation elements used to derive your answer.
2. Locate all the features identified in question 1 on the high altitude color infrared image (fig. 7, p. 37). For each feature discuss the interpretation elements which allow you to identify it on the high altitude scene. If the interpretation elements change from the low altitude to the high altitude image provide a brief explanation as to why these changes occur.
3. What is the primary interpretation element used in computer classification of Landsat imagery?

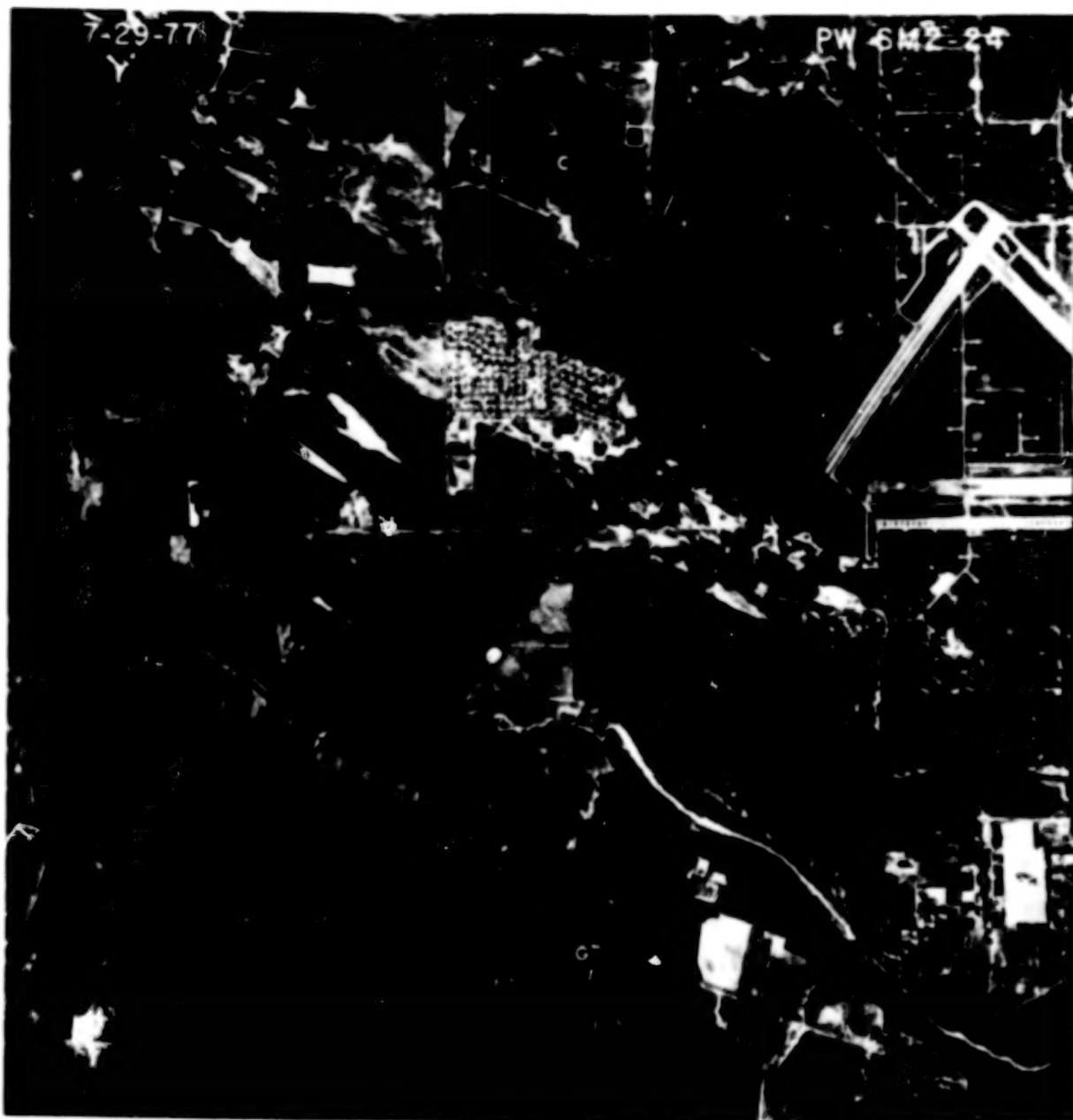


Figure 12.— Portion of ICARUS site, 9" x 9" image provided at scale of 1:20,000. Airport, upper right also on Figure 14. CERES site.

CERES

CERES (fig. 13) required solution to the problem of land-use/cover classification within an agricultural context. CERES presents a multiseasonal use and cover situation which undergoes temporal change. The field task required on-site identification of crops plus land-use/cover classification and mapping. Further analysis of the site was completed in a laboratory situation which required a third level breakdown of the U.S.G.S. Level II (Anderson, 1976) land-use/cover classification and map (fig. 9). This task was completed with the use of multiscale and multisensor (U-2 CIR, and large scale color vertical) imagery. Supporting materials included a 1:24,000 USGS topographic map, 1:250,000 soils map of the area, and a 1977 California Water Resources Department land use map. Additional data were extracted from a mylar Landsat digital land use classification map registered to the 1:24,000 Santa Maria topographic map. Workshop participants were also required to determine the areal extent of the multiseasonal crops. This task required the individual to use a metric grid planimeter which was provided in the learning kit (fig. 11, p. 43).

Remotely sensed materials can also provide valuable data for monitoring environmental change. Images taken over a given time period, for example Landsats 2 and 3 every ninth day coverage over a one year period, provide an excellent time-data base for change analysis. Traditionally, change detection required periodic map analysis and regular on-site visitation. Frequent map updating is often limited due to the high cost of map compilation and printing. Regular on-site visitation is expensive in both human time and labor costs. Very often a site may be virtually inaccessible; a situation which remotely sensed materials can rectify.

CERES Field Problem

Using the following land cover and land use classification system for use with remote sensor data, *classify* and *map* land use at this site. It is suggested that you not only classify and map this immediate site but also the surrounding area which can be observed from where you are standing.

Level I	Level II
1. Urban or built-up land	11 Residential
	12 Commercial
	13 Industrial
	14 Transportation, communications, and utilities
	15 Industrial and commercial
	16 Mixed urban or built-up land
	17 Other urban or built-up land
2. Agricultural land	21 Cropland and pasture
	22 Orchards, groves, vineyards, nurseries, and ornamental horticultural areas
	23 Confined feeding operations
	24 Other agricultural land



Figure 13. - Portion of CERES site, 9" x 9" image provided at scale of 1:20,000. Bottom right cover photo site is looking northwest from service road west side of freeway near water storage due south of "h" at edge of marine terrace.

Level I	Level II
3. Rangeland	31 Herbaceous rangeland 32 Shrub and brush rangeland 33 Mixed rangeland
4. Forest land	41 Deciduous forest land 42 Evergreen forest land 43 Mixed forest land
5. Water	51 Streams and canals 52 Lakes 53 Reservoirs 54 Bays and estuaries
6. Wetland	61 Forested wetland 62 Nonforested wetland
7. Barren land	71 Dry salt flats 72 Beaches 73 Sandy areas other than beaches 74 Bare exposed rock 75 Strip mines, quarries, and gravel pits 76 Transitional area 77 Mixed barren land
8. Tundra	81 Shrub and brush tundra 82 Herbaceous tundra 83 Bare ground tundra 84 Wet tundra 85 Mixed tundra
9. Perennial snow or ice	91 Perennial snowfields 92 Glaciers

CERES Laboratory Problem

Using the data collected from your CERES field notes plus the remote sensing materials in your kit, *classify* more specifically the Level II land-use information you gathered for CERES (how can you "break down" the 21 cropland and pasture classification?). What limitations can you identify with the 21 category classification; how do the various remote sensing materials (color verticals, oblique CIR, U-2, CIR, Landsat computer classification) help solve the problem?

Using the kit materials and your CERES field notes *map* the multiseasonal crops at CERES. Map one square kilometer centered on the intersection of *Battles Road* and *Highway 101* in addition, *measure* the area of these multiseasonal crops you have classified and mapped. Use the grid planimeter in your kit.

AQUARIUS

The AQUARIUS site (fig. 14) provided a situation which required analysis of environmental change that occurred in the agricultural as well as the urban fringe element of the site. Additionally, the site provided an opportunity for disaster assessment as a result of recent flooding of the Santa Maria River. The field task required on-site visual assessment, analysis of multisensor and multiscale



Figure 14.— Portion of AQUARIUS site. Bridge at "U" washed out by flood at time of workshop. 9" x 9" image provided at scale of 1:20,000.

imagery plus use of the USGS 1:24,000 topographic map. The corresponding laboratory problem required the user of the above materials plus the digital Landsat land use map to determine the type change during a given 7 year period. The problem also required documentation (via mapping) and measurement of the change.

Remotely sensed materials provide excellent source material for documentation of the urban landscape, especially urban morphology. Identifying, documenting, and monitoring urban land use and change has traditionally been a challenging task for the urban photographer. Both visual and digital products, at a variety of scales, can become very effective tools for recording urban phenomena.

AQUARIUS Field Problem

Using the 1:24,000 topographic map, the low altitude color vertical photos, and the U-2 false color IR photo of the AQUARIUS site, identify the *changes* which have occurred in both the *agricultural* and *urban fringe* elements of this site.

Using the above map and remote sensing materials plus your own visual observations, assess current environmental damage at this site.

AQUARIUS Laboratory Problem

Using the remote sensing materials in your kit plus your AQUARIUS field notes, how has the AQUARIUS site *changed* from 1971 to 1978? Specifically, what *agricultural* and *urban fringe* elements of the landscape have changed?

Using your field notes and remote sensing materials *map* and *measure* 4 square kilometers with the grid planimeter (fig. 11) on your kit. Center the four square kilometer area around the spot you were standing at the AQUARIUS site.

Using the Landsat computer land use/cover classification printout, determine whether the land use/cover changes had occurred at the time of the Landsat overflight. How useful is the Landsat computer output in terms of supplying *change detection* information; how useful is it in supplying *disaster assessment* information?

POLIS

POLIS (fig. 15) represented an urban site posing the problem of monitoring and documenting urban land use and land-use change. The POLIS field task required on-site acquisition of parcel land



Figure 15.— Portion of POLIS site, 9" x 9" image provided at scale of 1:20,000. See figure 3, p. 13 (left) for roof platform high oblique to the east from the shopping center parking building ("P") and ground platform view (right) to southwest from park at northeast corner of intersection "B". Note part of CERES site "C" (crop) and "O" (oil refinery) in southeast corner.

use data, development of a land use classification system, and mapping of land use change. Supporting materials included a large scale (1:2400) parcel base map, the digital Landsat land use map and low altitude color vertical photographs. The POLIS laboratory problem required assessment of land-use/cover change over a 7 year period using multitemporal, multisensor, and multiscale imagery (the U-2 CIR and large scale color photographs were taken at different time periods). Workshop participants were also required to measure land use change which had occurred during 1971-1978.

During the course of the Landsat conference participants were introduced to a variety of geographic problems which could be solved by using remotely sensed imagery. The workshop terminated with a timed examination (titled "Timed Laboratory Problems in Remote-Sensing Applications") which was administered to all participants. The examination (pp. 55-57) was designed to present a series of geographic problems which could be solved by using remotely sensed imagery. Problems covered the spectrum from geographic education to classification of vegetation in Alaska. The first part of the examination limited selection to one sensor product per problem, while the second part allowed the participant to choose a combination of sensor products. Answers, pp. 58-59, with a short reason for their selection, were posted the last day of the workshop; participants were permitted to keep the problems and examination questions for future reference. In addition, the examination and explanations were mailed to all participants.

POLIS Field Problems

At POLIS you will observe the morphology of the urban environment. The first task requires that you locate the POLIS site on both the 1:24,000 topographic sheet and low altitude vertical photos. How does the present site differ from the site on the vertical photos? How does the site differ from the site as symbolized on the topographic map? Why? Compare the Landsat computer digital land use printout with existing land use; how does it differ?

Using the large scale map, *classify* existing parcels at the POLIS site.

POLIS Laboratory Problem

At POLIS you observed temporal change in an urban environment. Using your POLIS notes and kit photos, images, and computer printout, *map* the *changes* which have occurred at POLIS during the 1971-1978 time period. How has the old CBD structure changed at POLIS; what remote sensing products have aided you in making your decision concerning this change?

Measure, using the grid planimeter, the land use/cover changes which have occurred from 1971-1978. *Measure* the landscape change within a 1 square kilometer area centered on the intersection of MAIN and BROADWAY.

Based upon the Landsat computer printout of land use/cover for POLIS, determine whether the land use conversions had occurred at the time of the Landsat overflight. How useful is this type of Landsat material in identifying changes in an urban environment? What contribution will Landsat 3 data provide?

TIMED LABORATORY PROBLEMS

IN

REMOTE-SENSING APPLICATIONS

During this workshop you have had a chance to collect ground information and extract data from several different types of remote-sensing products. Your field and lab experiences for CERES, AQUARIUS, POLIS, and ICARUS have demonstrated the usefulness and limitations of remote-sensing technology.

Given the following list of sensors, evaluate the effectiveness of each sensor system for a given geographic situation or problem.

1. Low-altitude color oblique
 2. Low-altitude CIR oblique
 3. Low-altitude color vertical
 4. High-altitude CIR vertical
 5. Visual Landsat images
 6. Computer-processed digital Landsat
 7. Landsat 3 thermal IR
- I. Select the system which would alone best serve the need. Place the appropriate number (from above) after the situation.
- A. You are all elementary school teachers with limited transportation, funds, and equipment. You would like your sixth grade class to develop a spatial awareness of the environment near the school. In addition, you would like them to construct a map from the remote sensing material.
-
- B. You are a water conservation district official desiring to accurately determine the acreage of inundated cropland in the Mississippi River basin caused by recent flooding.
-
- C. You are a researcher for the National Weather Service and it is your duty to develop an atmospheric model which will predict how cities (as urban islands) affect regional climate.
-

- D. As a member of the U.S. Forest Service it is your duty to acquire remote-sensing materials to aid you in determining the acreage of a fire-ravaged section of land in a nearby national forest. Time is of critical importance, for seasonal rains may start at any time, thereby causing erosion and landslides. The precise acreage must be determined in order that grass seed may be planted to help re-establish ground cover to help prevent serious erosion.
-

- E. You are the county planning director and it is your duty to contract remote-sensing materials which will provide the base land use inventory for your county's master plan. The materials will be used by your staff to compile a land use inventory map at an RF of 1:100,000.
-

- F. You are taking inventory of buildings in an industrial complex and you desire information on relative heights of buildings in the complex. You have limited funds for acquisition of remote sensing materials. What remote sensing product would meet your requirements?
-

- G. You would like to classify and measure impervious urban surfaces in Los Angeles for the purpose of relating land use to quality of storm water runoff. What type of remote-sensing product would help you?
-

- H. You would like to demonstrate to your senior high school geography class the different types of vegetation which can be found near the school (fields of grain, a forested area, and a small swampland area). What type of sensor product would help you at this task?
-

- I. You are a USGS official and it is your duty to generate maps of vegetation for a future environmental impact report for the North Slope of Alaska. This large area requires that your vegetation assessment data be obtained from remote-sensing materials.
-

- J. You are a geologist and it is your duty to update a "fault map" of northern California. What remote-sensing product would help you?
-

II. Using the sensors listed on page one of these problems, which *combinations* (two) of sensors most effectively meet user needs?

A. Serious flooding along the Ohio River caused several thousand acres of cropland to be inundated. As a soil conservationist it is your duty to determine the type of land covered by the flood water plus measure the flooded acreage. What combination of sensor products would you use?

B. Your senior high school geography class project requires one student to map and measure the various vegetation types located at a nearby field site. The student would also like to orient the other class members as to the relative location of the field site and the school. What sensor products would help this student?

C. Your environmental firm has the requirement to collect land use information on a multicounty-wide (4) project. You must not only collect and classify the data but you must provide your client with a finished land use map. What sensor combination would you use?

ANSWERS TO REMOTE-SENSING APPLICATIONS QUESTIONS

- I. A. 3-low-altitude color vertical
Key words: spatial awareness of the environment near the school, map; large scale vertical photo needed (small area with great detail) plus photogrammetric properties for mapping.
- B. 5-visual Landsat images
Key words: acreage of inundated cropland, Mississippi River basin; extremely large, therefore a need for a small scale product plus one on which a planimeter could be used to determine inundated area.
- C. 7-Landsat 3 thermal IR
Key words: atmospheric model, cities as urban islands (heat islands), regional climate; requires a system to detect emitted EM or heat for urban areas around the world. Landsat 3 will provide a means to monitor these heat islands on a regular basis.
- D. 3-low-altitude color vertical
Key words: section of land in a National forest, time factor, determine area; requires relatively large scale photos, plus vertical requirement in order to perform area measurements. Large scale CIR could also be used. Time factor may be too critical to obtain U-2 high altitude CIR.
- E. 4-high-altitude CIR vertical
Key words: land use inventory, county area, inventory map at 1:100,000; relatively small area, need detailed data for land use, U-2 high altitude photography can be contracted at approximately the required RF to generate the map.
- F. 1-low-altitude color oblique
Key words: relative height of buildings; obliques give good perspective view, verticals would be necessary if *exact* height information was needed.
- G. 3-low-altitude color vertical
Key words: urban area, land use, quality of storm water runoff; relatively large scale product needed to acquire detailed information concerning land use within the urban area.
- H. 2-low-altitude CIR oblique
Key words: vegetation types, grain crop, forested area, swamp; three distinctive vegetation types resulting in three visually distinctive tonal signatures. CIR film will record the reflected IR of each of these unique vegetation types.
- I. 6-computer-processed digital Landsat
Key words: North slope of Alaska, vegetation, vegetation assessment data; large area, small scale product needed to detect vegetation types as accurately as possible. Digital products can be used to classify, flag unique areas, and provide pixel by pixel assessment.

J. 5-visual Landsat

Key words: fault map and northern California; regional area with small scale overview. Enhanced visual Landsat would be extremely useful – geometric and photometric distortion can be reduced to sharpen image and help identify lineaments.

II. A. 5/6-visual and computer-processed digital Landsat

Key words: flooding along Ohio River, several thousand acres of inundated cropland, type of crop covered, measure flooded acreage; large area with need to accurately classify farmland. Visual Landsat images (pre/post flood) could be used for visual assessment. Digital Landsat (pre/post) is ideal for classification and accurate measurement of flooded area.

B. 1 or 2 and 3-low-altitude color or CIR oblique and low altitude color vertical

Key words: map and measure vegetation types near school, orient as to relative location of field sites and school; low altitude (large scale photos) needed to determine detailed crop types site close to school which would allow students to gather field data and develop a crop calendar. Vertical needed to map and measure acreage of various crops. Obliques are good for perspective views.

C. 4/6-high-altitude CIR vertical and computer-processed digital Landsat

Key words: land use information on a multicounty (4) wide project, collect and classify plus furnish a land use map; high altitude, CIR products to cover the area (low altitude would require a multitude of photos) plus digital Landsat to provide a land use classification. U-2 underflights are often flown in support of Landsat projects on the day of the Landsat overflight to correlate the two sensor data products.

REFERENCES

- Higgs, Gary: "Geographical Review" from *Geographical Record, Remote Sensing: Dawn of the Age of Application*, vol. 66, no. 1, January 1976, pp. 95-96.
- Anderson, James R., et al.: *A Land Use and Land Cover Classification System for Use with Remote Sensor Data*, Geological Survey Professional Paper 964, USGPO, Washington, D.C., 1976.

Chapter 7

TEACHING/LEARNING PRINCIPLES

Donna B. Hankins* and William H. Wake

INTRODUCTION

The Landsat C Educators and Users Workshop provides an excellent model for other training programs and educational courses in remote sensing.

Transfer of remote-sensing technology is a multiple problem with many separate and distinct parts differing according to the level of the participants, the nature of the course (general or single topic), duration, facilities available, and other factors. However, in every program at every level the need for orientation to the program, theoretical foundations, and practical problems – including provision for field work – arises.

Learning must take place before the technology can be applied. Therefore there is a major need to clearly identify both general and specific training tasks. Clearly the potential remote-sensing user community is enormous, and the teaching and training tasks are even larger.

At the same time there are some quite basic rules and underlying principles that may be synthesized and applied at all levels – from elementary school children to sophisticated and knowledgeable adults.

These rules and principles can be worked up rapidly and simply. Some are indigenous to all elements of a training course, others are specific to a single element.

This chapter attempts to outline, in brief summary form, the basic rules applying to each of the six major elements of any training course and the underlying principle involved in each rule. The six identified major elements are:

- Field Sites for Problems and Practice
- Lectures and Inside Study
- Learning Materials and Resources (The Kit)
- The Field Experience
- Laboratory Sessions
- Testing and Evaluation

*Director, Remote Sensing Technology Transfer Project, Humboldt State University, Arcata, California.

FIELD SITES FOR PROBLEMS AND PRACTICE

Basic Rules

Know your intended audience. Match site type and complexity to the level of competence and physical capabilities of the students.

Sites must be reasonably accessible.

Use public land or obtain permission to enter, in writing, from the owner or manager in advance of the workshop. Be sure to bring this policy, and any restrictions on movement, to the attention of the class.

Give sites names related to natural features, use (i.e., Ceres, agriculture; Aquarius, water), or place location rather than numbers.

Select sites for specific purposes. Include specialized sites with only one or a very limited range of features of major regional importance, and at least one site with a broader range of features indicative of the regional complex.

Pick sites familiar to the trainers whenever possible, and orient the trainers to the sites relative with the site-oriented problems to be assigned the students. This needs to be done regardless of the familiarity of the sites to the training team. It should also include orientation to the route to be traversed.

Principles Involved

Build competence by establishing confidence. Select sites that are not too complex or subtle for class to read and interpret.

Minimize travel time to avoid distractions and boredom.

Establish friendly relations with landowners/managers to maintain a sound learning situation uninterrupted by unpleasant charges of trespassing and possible legal action, to ensure access to the property, and to teach by example.

Avoid hierarchies associated with numbers to enhance concentration on environmental and land use patterns.

Use of sites with simple, strongly delineated patterns and a limited range of features speeds recognition, firmly sets the bases of identification, and facilitates mastery of minor, detailed, variations. Use of one or more sites with a broad range of environmental and use characteristics representative of the regional pattern enables the study of interrelations and interactions of the several elements including minor elements. It also increases capabilities of separating specific elements in a complex, and builds understanding of the nature and processes of the particular region. Finally, it enhances understanding of the regional concept criteria for delineation of a region, and appreciation of the complexity of all regions, even those considered as single-factor or simple regions.

Ensuring the trainers' knowledge of the sites and traverse route, the reasons for their selection, and the relations between the field characteristics and problems based on the field work is necessary to optimize the benefits of the field experience.

LECTURES AND INSIDE STUDY

Basic Rules

Lectures and inside study should match the expected understanding and competence levels of the students. Lecture sessions should move from basic theory of remote sensing and the electromagnetic spectrum to more complex subjects. The sessions should have a graded sequence of subject matter, and the lecturer should not try to cover the waterfront in one session. (The exceptions to this, of course, are the very important introductory and concluding sessions which, respectively, set the nature and scope of the course, and then sum it up. These sessions are often of shorter duration than the specific content lectures.) Cover one major segment well, with an internal progression or development or difficulty. In large programs with mixed audience capabilities, such as the Landsat C Workshop, this will involve development of parallel, simultaneous sessions with beginners separated from advanced participants.

Lectures, especially for short courses, must be geared to visual materials and discussions that fit the field sites to be visited. Some examples of other parallel areas may be useful, and occasionally imagery of a contrasting area or time frame can help to firm up a concept, principle, or relationship. Basically, however, the instructor should base visual materials on the places to be visited.

Materials must be clear and fit the field sites. Features must be readily identifiable (in terms of scale, resolution and complexity) at the capability level of the class.

Principles Involved

Help the students to be successful to build their morale and interest, but avoid putting them to sleep by excessive recounting of material they have already mastered. The latter does not mean the elimination of selective point reinforcement, nor of brief iteration to set a relationship or expand a topic.

Build difficulty of information and complexity of techniques by progressive stages to catch and hold interest by developing knowledge and understanding in an orderly manner. Do not discourage the learners by presenting a kaleidoscope which the students cannot separate to its components.

Selection of lecture examples that are directly related with or as closely parallel to the field sites as possible will minimize confusion concerning field and laboratory problems as well as aid in grasping the subject matter of the lecture. It will also reinforce the participant's identification of signatures of features and relationships to be worked with in field and laboratory problems, and build their competence by enhancing their confidence that they are familiar with the features and characteristics of the training area.

Encourage the students by grading the difficulty of identification to the upper limit of, but not beyond, their capability level. This will push them to master the material at the same time that it promotes factual learning, understanding, process mastery, and therefore builds confidence. Present true images (color scales, etc.) for study to avoid creating false mental images and misconceptions. The students must study reality to learn reality.

LEARNING MATERIALS AND RESOURCES (THE KIT)

Basic Rules

A most important rule is to create a kit based on a typical real life problem, or a carefully developed – and very plausible – hypothetical problem around which to mold lectures, learning materials, and field and laboratory sessions. The kit should include appropriate remote sensing imagery and specifications of the assigned problems, maps, and other supplementary materials related with the problem, the field sites, and the larger context region. If one or more problems are to involve a hypothetical region in addition to the real-world region to be studied, the description of the hypothetical region should also be included in the initial kit.

Materials must be manipulative, and those to be used in the field should be waterproofed, and contained in a sturdy stiff-backed notebook. The cover should have flaps or pockets in the front/back to carry pencils, pens, erasers, protractors, scales or rulers, graphic planimeters, etc., provided in the kit and/or added to by the student.

The kit must also include a course outline and schedule, reading list, supplemental bibliography, and if interviews are included in the problem, a set of interview forms (unless developing such forms is part of the problem) and a list of persons, or types of persons, to be interviewed.

Principles Involved

The single simple principle here is that real problems or hypothetical problems that can be accepted as possible real life problems, create better understanding and interest which promote acquisition of knowledge and mastery of techniques.

Be practical, if the student cannot readily carry and use the learning materials, interest levels and learning rates drop rapidly.

Help the students keep track of what is coming, what has been covered, what is required, and, very important, help them find the information needed, encourage them to come back with questions and problems, and stimulate and help them to go on and learn more than is covered directly in the course.

THE FIELD EXPERIENCE

Basic Rules

Keep the student group(s) in the field small enough to manage by dividing the class into small working groups. If transportation facilities permit, take each group to a different field site, and rotate site visits rather than have all

Principles Involved

This provides maximum exposure to all facets of the field experience, and provides greater opportunities for questions and answers from instructors. It also makes field logistics and safety much simpler.

Basic Rules

members of a large class visit a field site at the same time. If the class is small enough to travel as a single group, visit the single-factor, specialized field sites first, then visit the complex multifactor site(s) to follow the process of sequential building outlined earlier.

Include problems based on the route traverse from, to, and between the sites at which stops are to be made. If two or more vehicles are used, be sure that the instructional staff is as evenly distributed among them as possible. Further, be careful to avoid over-packing of vehicles to allow room for imagery, map, and notebook manipulation. This "windshield interpretation" may involve the use of special imagery and perhaps even extra maps, particularly if the field sites are widely separated.

Select field sites that are as close to the training facility and to one another as possible. Try to keep running time of each leg of the route to 15 minutes or less. The major exception to this is a field trip designed to provide experience in gathering information from moving vehicles. If this is the case, be sure to schedule several stops or learning will drop to very low levels. Busses or vans are preferable to sedans because their higher windows provide a better view of the landscape, and they provide greater head, leg, and elbow room than most automobiles.

Provide a classroom introduction to the field site(s) the day or evening before the field trip. Use ground level, low-altitude oblique and

Principles Involved

Time is always at a premium, do not waste it by having the class simply ride around the countryside idly discussing baseball scores or TV shows. Boredom sets in rapidly on such rides, and results in lost time at each stop as well as lower levels of interest. The alternative of highly spirited involvement in matters not related with the course is even more difficult to overcome. It is much easier, and more effective, to maintain interest in course-related matters than it is to rebuild it at each stop. This may be accomplished by en-route problems or less formal but planned verbal challenges. These may involve identification of signatures or relations such as will be studied more thoroughly at the field sites. Alternatively, they may be based on signatures/relationships that will not be represented at any site to expand the total field experience. This will also enable the study of transitions from one environmental/use pattern to another with particular attention to interface zones.

Short runs make it much easier to maintain interest, yet can contain considerable variety of features and characteristics and significant transitions from one environmental or land use pattern to another. "Windshield interpretation" is a valuable skill, but it is tiring as it requires more intense concentration and much more rapid recognition and use of materials than fixed-site field study hence the importance of breaks.

This creates a feeling of familiarity with and understanding of even new terrain, and vitally increases learning and development of field

Basic Rules

vertical, medium and/or high altitude, and Landsat imagery of the field sites on 9 in. X 9 in. transparencies or 35 mm slides which match imagery in the field kit. If it is not possible to obtain transparencies, hard (paper) copy may be used with an opaque projector though this is usually much less satisfactory because of the loss of brilliance and resolution. Review the materials, apparatus, and approach to be used in the field. Provide large Landsat photographic products mounted on masonite and overlaid with mylar upon which field sites can be marked clearly. Brief the class on climate, geology and geomorphology, soils, hydrology, vegetation, major landmarks, archeological significance, and current and historical land uses, and on the route to be followed. Clearly review what the class will be required to do in the field, centering around specific problems. These problems should be solvable within the capability level of the class, and should be clear to all members. Also include information on what to wear and bring, food arrangements if any, and stops. The lecture may constitute a separate session or part of a pretrip laboratory in which basic problems (such as scaling, major features, and pattern locations) can be worked out. A post-trip laboratory should be provided to permit completion of the field related problems.

Principles Involved

skills. It will demonstrate a set of options for approaching any field problem using remotely sensed data, and finally it will provide a chance to really use techniques rather than spending time listening to a long lecture in the field as preparation for doing so. Give the lecture in the briefing! Do field work in the field! Use materials provided as they could be used in solving real life problems.

LABORATORY SESSIONS

Basic Rules

Laboratory sessions should intersperse lecture/discussion sessions to permit the students to firm up knowledge acquired in the lectures by application to problems related with the lecture topics. Laboratory sessions should both precede and follow the field trip.

Principles Involved

The principle of this rule is to maximize learning from the lectures and the field trip. Interspersing lectures with laboratories covering a maximum of two or three lectures is preferable to one long laboratory covering all the lectures because it enables the students to concentrate on application of a limited body of material while it is fresh in their minds and relatively simple by being limited in scope.

Basic Rules

Laboratory sessions should use materials seen or used before.

A final lecture and laboratory session should be devoted to application of information and knowledge gained at the field training sites to one or more other, real or hypothetical, areas. The features, characteristics, and patterns of the training sites should be used as the bases to answer questions and make decisions concerning the use of the newly introduced areas.

Laboratory sessions should be based on sets of problems that can be completed within the laboratory period.

Another set, to be completed at home or in individual nonscheduled, laboratory sessions may be added with significant benefit, but care must be taken that it does not entail excessive amounts of time.

There should be a brief re-orientation to the requirements of each laboratory period with review of the specific problems entailed and clarification of their purposes as well as their nature.

Principles Involved

The purpose of the laboratory is to clarify and firm up knowledge of subjects covered in lectures or field work by working with the data.

This will permit emphasis of principles of interpretation and their use in broader and alternate regions making the students' learning much less site-specific and therefore more widely applicable, i.e., more practical for real world use.

The students gain an important sense of satisfaction at completion of a project within the specified period.

The students should understand clearly all aspects of each laboratory including its purposes and goals. It is confusing and discouraging to face unclear assignments. This results in rapid loss of interest and lowered learning levels.

TESTING AND EVALUATION

Basic Rules

Testing should take place by section, and not be restricted to a single test covering the entire course. Tests on lecture materials may be open book, and should be graded and returned as quickly as possible - preferably before the next test. Test separately on the field experience. Finally, the laboratory problems should be graded. The final examination should incorporate all elements of the course, preferably in comprehensive development of one problem.

Principles Involved

Too much crammed into too short a time creates neither a good learning situation nor a good testing environment, and a test should combine both. Short tests on each section and a comprehensive, rather than a minutia-regurgitating, final examination provides a more valid testing of knowledge acquired and also adds to the student's knowledge and understanding in the process of taking the examination.

Basic Rules

This may be given as a final laboratory problem or a take-home examination.

Evaluation of the course should take place before the students leave. Brief evaluations of each subsection as well as an overall evaluation will be useful. A followup questionnaire six months after the course will provide information concerning the students' reactions to it. However, care must be taken to avoid excessive loss of instructional time to evaluations which would ensure that the evaluations would be increasingly negative, and rightly so.

Principles Involved

Some sections will be better received than others, and some received very negatively. Brief evaluation of each segment makes it possible to ensure the responses separate good and bad sessions and additional useful insight into causes for the reactions. Final evaluation helps to provide a perspective on the course as a whole. Followup evaluation is usually more valid since students have had time to absorb and consider the course as a whole and to use their learning in it. However, important details are lost over time, so this should not be the only evaluation.

APPENDIX A
CONFERENCE PROGRAM
LANDSAT
VIEWS OF OUR NATURAL RESOURCES AND LAND USE

March 2-5, 1978

**SANTA MARIA, CALIFORNIA/
NASA WESTERN LAUNCH OPERATIONS**

Sponsored by:

National Council for Geographic Education
California Council for Geographic Education
National Aeronautics and Space Administration

Supported by:

California Science Teachers Association
National Council for Geology Teachers -

Far Western Section

PROGRAM

Thursday - March 2

6:00 p.m. - 10:00 p.m.

Registration: Riviera Room, Vandenberg Inn

8:30 p.m. - 10:00 p.m.

No-Host Get-Acquainted Time, Vandenberg Inn

Friday - March 3

7:30 a.m. - 8:30 a.m.

Late Registration - Vandenberg Inn

8:30 a.m. - 10:45 a.m.

General Sessions:

Santa Maria High School Auditorium

901 S. Broadway, Santa Maria, California

(High school is within walking distance of Vandenberg Inn)

8:30 a.m. - 9:00 a.m.

Moderator: Dr. William Wake,

California State College, Bakersfield

Landsat

Dr. Stanley C. Freden

Chief: Mission Utilization Office

NASA Applications Directorate

NASA-Goddard Space Flight Center

Workshop Briefing

9:00 a.m. - 9:45 a.m.

Visual Interpretation

Dr. William Finch, Department of Geography

San Diego State University

9:45 a.m. - 10:00 a.m.

Break

10:00 a.m. - 10:45 a.m.

Moderator: Donna Hankins, Humboldt State University

Instrumented Interpretation

Ralph Perry

President: Pilot Rock

Arcata, California

Dr. Lawrence Fox III
Technical Coordinator
Northern California Remote Sensing Project
Humboldt State University

10:45 a.m. – 11:05 a.m.

Break

11:05 a.m. – 11:50 a.m.

Concurrent Sessions I: Interpretation of Special Signatures

- A. Santa Maria High School Auditorium
Moderator: Dr. John E. Estes, University of California, Santa Barbara

Rangeland, Forestry and Agriculture
Dr. Robin Welch
Director of User Assistance
Western Regional Applications Program
NASA-Ames Research Center

- B. Vandenberg Inn, Riviera Room A
Moderator: Steven P. Kraus, University of California, Santa Barbara

Geology and Energy
Dr. Floyd F. Sabins
Senior Research Associate
Chevron Oil Field Research Company
La Habra, California

- C. Vandenberg Inn, Riviera Room C
Moderator: Dr. Richard A. Ellefsen, San Jose State University

Water and Land Use
Dr. Leonard W. Bowden
Professor of Geography
Department of Earth Sciences
University of California, Riverside

11:50 a.m. – 12:45 p.m.

Lunch

Exhibits Open – Vandenberg Inn

12:45 p.m. – 1:45 p.m.

Concurrent Sessions II: Imagery Applications

A. Professional Users Applications

1. Vandenberg Inn, Matador Room
Moderator: Dr. Richard A. Ellefsen
San Jose State University

Environmental Analysis and Resource Exploration
Dr. David Schwartz, Department of Geography
San Jose State University

2. Vandenberg Inn, Room C
Moderator: Dr. John E. Estes
University of California, Santa Barbara

Land and Water Use and Misuse
Dr. Stanley A. Morain, Director
Technology Application Center
University of New Mexico

B. Education User Applications

1. Vandenberg Inn, Toreador Room
Moderator: Garth A. Hull, NASA-Ames Research Center

Elementary
Dr. Haig Rushdoony, Department of Geography
California State College, Stanislaus

James Boyle, Assistant Professor of Education
NASA-Chico State University

William Horvath, Assistant Professor of Education
NASA-Chico State University

2. Vandenberg Inn, Room A
Moderator: B. Michael Donahoe
NASA-Ames Research Center

Secondary
Donna Hankins
Humboldt State University

Clarice Lolich, Assistant Professor of Education
NASA-Chico State University

3. Santa Maria High School Auditorium
Moderator: Richard McKinnon
Allan Hancock College, Santa Maria, California

Higher Education
Joseph Frasca
Sonoma State University

Dr. Harry B. Herzer, III
Associate Professor of Education
Chico State University

1:45 p.m. – 2:05 p.m.
Break

2:05 p.m. – 5:00 p.m.
General Sessions: Santa Maria High School Auditorium

2:05 p.m. – 2:35 p.m.
Moderator: B. Michael Donahoe, NASA-Ames Research Center

Western Regional Applications Program
Dr. Robin Welch, Director of User Assistance
Western Regional Applications Program
NASA-Ames Research Center

2:35 p.m. – 3:05 p.m.

Economics of Remote Sensing
Dr. Kenneth Craib
President, Resources Development Associates
Los Altos, California

3:05 p.m. – 3:15 p.m.
Break

3:15 p.m. – 3:55 p.m.
Moderator: Donna Hankins
Humboldt State University

The Role of Industry in Remote Sensing Applications
Lowell H. Brigham
Manager, Market Development
General Electric – Space Division
Beltsville, Maryland

3:55 p.m. – 4:05 p.m.
Break

4:05 p.m. - 5:00 p.m.

Industry Panel

Dr. Nevin A. Bryant, Earth Resources,
Application Group, J.P.L., Pasadena California

Dr. Fred B. Henderson, III, President
Geosat Committee Inc., San Francisco, California

Dr. Phillip G. Langley
Earth Satellite Corporation
Berkeley, California

Robert E. Tokerud, Asst. Director
Science and Applications Branch
Lockheed Electric Company
Houston, Texas

Eugene M. Zaitzeff, Program Development Manager
Earth Resources
Bendex Corporation
Ann Arbor, Michigan

6:30 p.m. - 7:30 p.m.

No-host Social Hour

7:30 p.m. - 9:00 p.m.

Santa Maria Barbecue, Holiday Inn
Master of Ceremonies: Dr. William H. Wake

Dinner Address: Industrial Perspective on the Landsat Opportunity
Barbara Williams
Program Manager, New Product Introduction
General Business Group International
IBM - New York

Saturday, March 4

8:00 a.m. - 8:20 a.m.

Field Trip Briefing
Santa Maria Veterans' Memorial Auditorium
Pine and Tunnel Street
Moderator: Dr. Richard Ellefsen
Chairman, Dept. of Geography
San Jose State University

Dr. John E. Estes
Associate Professor
Geography Remote Sensing Unit
Dept. of Geography
University of California, Santa Barbara

Dr. David Schwartz
Dept. of Geography
San Jose State University

Dr. William H. Wake
Dept. of Physics and Earth Sciences
California State College, Bakersfield

8:20 a.m. – 8:50 a.m.

Visual Interpretation and Application of Imagery to Field Study Areas
Eugene C. Napier, Representative
Western Region Geography Instrumented Program
Land Use Data and Analysis
USGS, Menlo Park, California

8:50 a.m. – 9:20 a.m.

Instrumented Interpretation and Applications of Imagery to Field Study Areas
Leonard Gaydos
Team Leader
USGS/NASA-Ames Research Center

9:20 a.m. – 9:35 a.m.

Load Buses

9:35 a.m. – 11:35 a.m.

Ground Truth Field Problems
a. Agricultural – rural (two types)
b. Central city area
c. Airport – urban-rural (interface)

Dr. Richard Ellefsen
Dr. John E. Estes
Joseph Frasca
Richard McKinnon
Dr. David Schwartz
Dr. William Wake
UC Santa Barbara Students

11:35 a.m. – 12:35 p.m.

Lunch – Waller Park, Santa Maria

12:35 p.m. – 2:45 p.m.

Ground Truth Field Problems – Complete Cycle of Four Sites

2:45 p.m. – 3:00 p.m.

Return to Santa Maria Veterans' Memorial Auditorium

3:00 p.m. – 3:30 p.m.

Break

3:30 p.m. – 5:30 p.m.

Ernest Righetti High School, Cafetorium
Laboratory Interpretation and Application
Problems
Evaluation of Workshop
Joseph Frasca and Staff

5:30 p.m. – 7:30 p.m.

Free Time

LAUNCH ORIENTATION

Santa Maria Veterans' Memorial Auditorium

Moderator: Garth A. Hull, NASA-Ames Research Center

7:30 p.m. – 8:30 p.m.

Landsat Accomplishments and New Landsat "C" Applications
Dr. Stanley C. Freden
Chief, Mission Utilization Office
NASA Applications Directorate
NASA-Goddard Space Flight Center

8:30 p.m. – 8:45 p.m.

The Perspective of Landsat Utilization by State and Local Government
A. Donald Goedeke
Office of Space and Terrestrial Applications
NASA Headquarters, Washington, D.C.

8:45 p.m. – 9:15 p.m.

The Launch of Landsat "C"
Luis Gonzales
Deputy Project Manager, Landsat Project
NASA-Goddard Space Flight Center

Sunday, March 5

7:45 a.m. - 8:00 a.m.
Depart for Launch

9:45 a.m. - 10:25 a.m.
Launch Window - Landsat "C"

11:00 a.m.
GOOD BYE. THANK YOU FOR COMING.

Planning Committee

B. Michael Donahoe
Dr. Richard A. Ellefsen
Dr. John E. Estes
Joseph Frasca
Donna B. Hankins
Garth A. Hull, Co-Chairman
Steve P. Kraus
Richard McKinnon
Frederick E. Mertz
Dr. Haig Rushdoony
Dr. David Schwarz
Douglas Stow
Larry Tinney
Dr. William H. Wake, Co-Chairman

Acknowledgements

NASA-WRAP, Ames Research Center
United States Air Force - Vandenberg AFB
United States Department of the Interior - EROS Data Facility
United States Geological Survey Geography Program and N.C.I.C., Menlo Park, California

Bendix Corporation
Earth Satellite Corporation
General Electric - Space Division
Geosat Committee, Inc.
IBM
Jet Propulsion Laboratory
Lockheed Electric Company
Pilot Rock, Inc.
TRW Corp.

Frederick's, Santa Maria
Santa Maria Chamber of Commerce
Santa Maria Joint Union High School District
Vandenberg Inn, Santa Maria

APPENDIX B

LANDSAT CONFERENCE QUESTIONNAIRE

Name (optional) _____

Title/Position (optional) _____

Affiliation (optional) _____

I. Employment:

A. Teaching

_____ N-6	_____ junior college
_____ junior high	_____ college/university
_____ high school	_____ graduate level
_____ industrial program	_____ governmental agency program

B. Applied research:

_____ private consulting firm
_____ governmental agency
_____ local/county
_____ state
_____ federal
_____ university affiliated research center

C. Other _____

II. Highest earned degree:

_____ undergraduate	_____ Teaching certification
_____ Associates	_____ M A/M S
_____ B A/B S	_____ Ph.D
_____ Other _____	

III. For what primary purpose will your knowledge of remote sensing be used?

- A. _____ teaching
_____ theoretical research
_____ applied research
- B. Please identify what level and/or field.

IV. Please comment on the familiarity you had with remote-sensing technology (none, a remote sensing course, advanced course work, research involving remote sensing technology, etc.) before the conference started.

WORKSHOP EVALUATION

I. My general impression of the LANDSAT C remote-sensing workshop was (please check one):

- A. _____ very pleased that I attended
B. _____ pleased that I attended
C. _____ satisfied
D. _____ disappointed

Why? _____

II. Would you attend a similar workshop on remote sensing in the future?

- A. _____ yes Why? _____
B. _____ no _____

III. Rate the following on a scale of 1 to 5 (1 = less than adequate, 3 = adequate, and 5 = more than adequate):

1 2 3 4 5

- A. quality of instruction _____
- B. breadth of material covered _____
- C. utility of your applications _____
- D. comparison with what you expected _____

IV. In general, please comment concerning the level of material presented. Was it too complicated, too simple, or adequate for your needs?

V. Check areas of the workshop which need improvement:

- A. _____ general instruction to remote sensing principles
- B. _____ general instruction to electromagnetic spectrum
- C. _____ field work and ground information
- D. _____ sensor operation
- E. _____ resource material
- F. _____ LANDSAT C sensors and operation
- G. _____ other (please specify) _____
- _____
- _____
- _____

VI. What field or area of remote sensing applications did you find the most informative? Why?

VII. What topics or applications would you have desired more information on? Why?

VIII. How will you use the materials and knowledge you acquired at this workshop?

A. _____ teaching

_____ theoretical research

_____ applied research

B. Please identify what level and/or field _____

IX. Please comment on the quality of materials which were provided at the conference. Did you find them useful?

A. NASA/private industry material and literature

B. NASA/NCGE/CCGE Field Kit

C. How do you plan to use the field/lab imagery kit which was supplied?

X. Please comment on the quality of the workshop, your satisfaction with it, and give us your suggestions for changes in future remote sensing workshops. (Please use space provided below.)

(Full page provided for responses)

APPENDIX C

PARTICIPANTS

Total Registration: 341

Distribution by Occupation:

State legislators:	3 (2 Arizona senators, 1 Oregon representative)
Federal, state, local government employees:	6
Private industry	33
Elementary Teachers:	32
High School Teachers:	53
Higher education faculty and students:	96
Adult Education:	3
Educators, level not indicated:	33
California Museum of Science and Industry:	6
Associations:	8
Not indicated:	13

Geographic Distribution of Participants

Arizona	2	California	312
Georgia	1	Hawaii	1
Indiana	1	Maryland	1
Michigan	1	Nevada	2
New Mexico	2	New York	1
North Dakota	2	Oregon	4
Texas	3	Utah	1
Virginia	2	Washington	1
Washington, D.C.	1	Wisconsin	1
		British Columbia	1
		Manitoba	1

Distribution by Options

I - 212, II - 17, III - 37, IV - 75

APPENDIX D

FACULTY

TOTAL 37

Government 7; Industry 9, Education 21 (elementary through higher education)

LECTURERS AND STUDENT ASSISTANTS

Geography Remote Sensing Unit, University of California, Santa Barbara:

Lecturers:

Steve P. Kraus
Larry Tinney

Student Assistants:

Edward Almanza	Cheryl Jones
Sue Atwater	Kalli Kull
Jay Baggett	Craig Light
Betsy Barber	Thomas Logan
Michael Cochran	Frederick Mertz
Ross Cochran	Greg Mohr
Michael Cosentino	Peggy O'Neill
Scott Davis	Rudolph Retamoza
E. Ezra	Donald Richardson
James Frew	Joseph Scepan
Caryn Gold	Douglas Stow
Wayne Hallada	Donald Taube
Cary Hansen	Tara Torburn
Heather Harvey	Susan Yates

Department of Physics and Earth Sciences, California State College, Bakersfield:

Edward Miller	Donald Terndrup
William Rosica	James Wardlow
George Stewart	

APPENDIX E

LEARNING KIT COSTS

The costs of the items listed below are much lower than unit costs for one or a few copies of each because 400 kits were made up for the workshop. For example, the 1:24,000 and 1:250,000 topographic maps cost \$0.87 and \$1.40 respectively instead of \$1.25 and \$2.00 each, and pro-rata costs of items such as the inter-negative are inversely related with the number of copies to be made from them.

Two additional factors helped to lower costs: (1) the workshop was presented as an extension course of the Office of Continuing Education, California State College, Bakersfield, so the soils map and other printed materials were produced at the campus Reprographics Center at lower than commercial rates, and (2) several items were contributed for which cost data are not available. Therefore, the itemized costs and the total cost of the kit will be misleading if those factors are not kept in mind. It is not feasible to attempt to list prices for smaller groups and commercial printing; however, the workshop costs might be of help in planning learning kits so they are itemized here.

4 low altitude window site 9 in. X 9 in. color prints @ \$2.23	\$ 8.92
1 U-2 CIR 9 in. X 9 in. color print	2.23
U-2 Transparency Internegative pro-rate17
1 Landsat CIR 9 in. X 9 in. color Xerox print37
1 Soils Map and Legend (2 sheets)03
1 Digitized 1:24,000 map transparency	3.18
Computer time pro-rate for digitization	1.47
1 1:24,000 USGS Topographic Map87
1 1:250,000 USGS Topographic Map	1.40
1 copy, Everyone's Space Handbook	3.90
8 35 mm low oblique slides of window sites (1 Ektachrome and 1 CIR of each site) and 1 CIR Landsat slide @ 0.08576
Film and Processing for window sites 35 mm slides, pro-rate006
1 "Field and Laboratory Experiences" problem and examination booklet, 11 pages, 2 sides13
1 Bibliography, 4 pages 2 sides16
1 9 in. X 9 in. mylar film for tracing09
TOTAL	\$14.62

CONTRIBUTED COMPONENTS

The costs of the following contributed components of the Learning Kit are not available. If the workshop participants had had to pay for them the cost per kit would have been several dollars higher. Without them the learning value of the kits would have been much lower.

Compilation and reproduction of 400 copies of the USGS Geography Program Land Use/Land Cover Map of Santa Maria at 1:24,000 scale, level 2 classification.

Reproduction of 400 copies of the State Department of Water Resources Land Use Map at 1:62,500 scale.

Compilation and Reproduction of 400 copies each of the 1:2,400 Polis Map and level 3 classification, and the 1:24,000 scale graphic planimeter by the CARTREMS Laboratory, Department of Geography, San Jose State University.

Compilation of the special Soils Map and Characteristics Sheet by James C. Wardlow, U.S. Bureau of Land Management.

400 Learning Kit folders and 400 supplemental kits of NASA information, plus contributions by the USGS Geography Program and National Cartographic Information Center, General Electric, Bendix, and TRW assembled for the workshop by the NASA Educational Program Officers.

One-half day helicopter flight time (as part of a regular training flight) to photograph low altitude oblique views of the window sites, U.S. Air Force, Vandenberg Air Force Base.

APPENDIX F

ADDITIONAL SELECTED REFERENCES

Field Study

- Commission on College Geography, Field Training in Geography, Technical Paper Number 4, Association of American Geographers, 1968.
- Hankins, D., A Practical Guide to the Use of Space and Aerial Photography in the Elementary and Secondary Classroom, Pilot Rock, Inc., 1976.
- Holtgrieve, D.; and Mahaison, C., Field Trips in Geographic Education: An Annotated Bibliography, Instructional Activity Series, 1A/G1, National Council for Geographic Education, 1976.
- Compton, R., Manual of Field Geology, John Wiley & Sons, Inc., 1962.
- Joyce, A., Procedures for Gathering Ground-Truth Information for a Supervised Approach to a Computer-Implemented Land Cover Classification of Landsat-Acquired Multispectral Scanner Data, NASA Reference Publications 1015, January 1978.
- Richason, B.; and Guell, C., Geography Via Aerial Field Trips, Do It This Way, No. 6, National Council for Geographic Education, 1965.
- State Water Resources Control Board, Manual of Practice, Low Altitude Aerial Surveillance for Water Resources Control, January 1978.
- Wood, E., Science from Your Airplane Window, Dover Publications, Inc., 1975.

Aerial Photography and Remote Sensing

- Anderson, J., et al., A Land Use and Land Cover Classification System for Use With Remote Sensor Data, U.S.G.S. Professional Paper 964, 1976.
- Avery, T., Interpretation of Aerial Photographs, Burgess Publishing Co. (3rd edition), 1977.
- Brosius, C. A.; Gervin, C.; Dr. Ragusa, J. M., Remote Sensing and the Earth. Available from Project Remote Sensing, Instructional Services Division, School Board of Brevard County, 1274 South Florida Avenue, Rockledge, FL 32955.
- Nixon, D.; and McCormack, R. E., Landsat, A Tool for Your Classroom, Social Education, official journal of the National Council for the Social Studies, vol. 41, no. 7, November-December 1977.

- Reeves, R. (ed.-in-chief): *Manual of Remote Sensing* (2 vols.), American Society of Photogrammetry, 1975. The Society also publishes several other books on aspects of remote sensing.
- Richason, B. (ed.): *Introduction to Remote Sensing of the Environment*, Kendall/Hunt, 1978, for the National Council for Geographic Education. A laboratory manual is also available.
- Sabins, F.: *Remote Sensing, Principles and Interpretation*, W. H. Freeman and Co., 1978.
- Short, N.; Lowman, P.; Freden, S.; and Finch, W.: *Mission to Earth, Landsat Views the World*, 1976. U.S. Government Printing Office, Washington, D.C. 20402 (Stock no. 033-000-00659-4).
- Tindal, M.: *Educator's Guide for Mission to Earth: Landsat Views the World*. U.S. Government Printing Office, Washington, D.C. 20402 (Stock no. 3300-00735-3).

Periodicals with Articles Relating to Field Work and/or Remote Sensing

- American Scientist, Sigma Xi.
- Annals of the Association of American Geographers, also The Professional Geographer.
- Astronautics and Aeronautics, American Institute of Aeronautics and Astronautics.
- California Geographer, The, California Council for Geographic Education.
- Current Geographical Publications and the Geographical Review, The American Geographical Society, New York.
- Functional Photography and Technical Photography, PTN Publishing Corporation.
- Journal of Geography, National Council for Geographic Education.
- Journal of Soil and Water Conservation, Soil Conservation Society of America.
- National Geographic, National Geographic Society.
- Photogrammetric Engineering and Remote Sensing, The American Society of Photogrammetry.
- Remote Sensing Quarterly (formerly RSEMS (Remote Sensing of the Electromagnetic Spectrum)), Department of Geography and Geology, The University of Nebraska at Omaha.
- Scientific American, New York, New York.
- Surveying and Mapping, American Congress for Surveying and Mapping.

Visual Teaching Materials

Sectional Aeronautical Charts scale 1:500,000, may be obtained at local aircraft rental operations, National Oceanographic and Atmospheric Administration, and other sources.

EROS Data Center, U.S. Geological Survey, Sioux Falls, S.D., imagery, tapes, publications.

General Electric Company: Space portrait of the United States, 46 in. X 36 in. CIR color litho of the U.S. from 569 Landsat images. General Electric, U.S. Portrait, P.O. Box 34, Norwood, N.J. 07648.

National Aeronautics and Space Administration centers: Regional Application Programs or NASA Educational Programs Offices: Ames Research Center, Moffett Field, CA 94035; Goddard Space Flight Center, Greenbelt, MD 20771 (including the Census Project); Johnson Space Center, Houston, TX 77058; Kennedy Space Center, FL 32899; Langley Research Center, Hampton, VA 23365; Lewis Research Center, Cleveland, OH 44135; Marshall Space Flight Center, AL 35812.

National Geographic Society, Portrait of U.S.A., Natural color mosaic of the U.S. from Landsat, RF 1:4,560,000 Natural Color: of G.E. Space Portrait (above), National Geographic Society, Washington, D.C. 20036.

National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Photo Geographic International, Photo-Atlas of the United States, Ward Richie, 1975.

Pilot Rock, Box 470, Arcata, CA 95521, slide sets, publications, Color Infrared Version of Portrait of U.S.A.

Remote Sensing Technology Transfer Project, Center for Community Development, Humboldt State University, Arcata, CA 95521 (Funded by NASA Western Regional Applications Program).

Technology Application Center, University of New Mexico, Code 11, Albuquerque, New Mexico 87131, slide sets and other imagery.

Local Aerial Surveyors, consult the yellow pages of the telephone directory under Aerial Surveys and related headings.

Geography and Cartography Texts

Monk, J., and Alexander, C. Physical Geography, Analytical and Applied, Duxbury Press, 1977 (esp. Activity 9, "Topographic Maps and Aerial Photographs" and following).

Muller, R., and Oberlander, J. (eds.) Physical Geography Today: Portrait of a Planet, CRM Random House (2nd edition), 1978 (esp. App. II, "Tools of the Physical Geographer").

Raisz, E.: Principles of Cartography, McGraw-Hill Book Co., 1962, esp. Ch. 2 "Airphoto Reading"; and Ch. 4 "Field Methods "

Robinson, A.; Sale, Randall; and Morrison, J.: Elements of Cartography (4th edition), John Wiley & Sons, 1978. (Esp. Ch. 6 "Remote Sensing and the Use of Air Photographs.")

APPENDIX G

CONTRIBUTORS

Preface: Benjamin F. Richason, Jr., Ph.D., Chairman, Remote-Sensing Committee, National Council for Geographic Education, and Chairman, Department of Geography, Carroll College, Waukesha, Wisconsin

Workshop Keynote Address: Barbara E. Williams, Formerly: Presidential Interchange, Executive Manager, Market Requirements and Planning, Landsat Follow-on Program, NASA User Affairs Division, Office of Applications, Currently: Program Manager, New Product Introduction, IBM Corporation-General Business Group/International, White Plains, New York.

Editor, Chapter 1, Chapter 2: William H. Wake, Ph.D., Professor of Earth Sciences (Geography), Department of Physics and Earth Sciences, California State College, Bakersfield, California.

Chapter 3: David E. Schwarz, Ph.D., Associate Professor of Geography, and Richard E. Ellefsen, Ph.D., Chairman, Department of Geography and Director of CARTREMS Laboratory, San Jose State University, California.

Chapter 4: Richard M. MacKinnon, M.A., Professor of Geography, Department of Social Sciences, Allan Hancock College, Santa Maria, California, and William H. Wake.

Chapter 5: Douglas A. Stow, Graduate Student and Research Assistant, John F. Estes, Ph.D., Associate Professor of Geography and Director, Geography Remote Sensing Unit, Department of Geography, and Frederick C. Mertz, Graduate Student and Research Assistant, Department of Geography, University of California at Santa Barbara.

Chapter 6: Joseph W. Frasca, Ph.D., Assistant Professor of Geography, Department of Geography, Sonoma State College, Rohnert Park, California.

Chapter 7: Donna B. Hankins, M.S., Director, Remote Sensing Technology Transfer Project, Humboldt State University, Arcata, California, and William H. Wake.

APPENDIX H

PHOTOGRAPHY CREDITS

Page iv

Top

Fifth Grade Class, Hort School, Bakersfield, California, Velma Wallace, Teacher, William H. Wake, California State College, Bakersfield.

Bottom

Landsat C Workshop Participants at a surface truth site, Benjamin F. Richason, Jr., Carroll College.

Figures 1, 3, 4, 5

William H. Wake, California State College, Bakersfield.

Figure 2

Kamila Plesmid, Remote Sensing and Technology Transfer Project, Humboldt State University, Arcata.

Figures 6 and 11

CARTREMS Laboratory, San Jose State University.

Figures 7 and 8

NASA.

Figure 9

USGS Geography Project, Menlo Park.

Figure 10

Geography Remote Sensing Unit, University of California, Santa Barbara.

Figures 12, 13, 14, 15

Courtesy of Pacific Western Aerial Surveys, Santa Barbara.

1. Report No. NASA CP-2155		2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle FIELD STUDY FOR REMOTE SENSING - AN INSTRUCTOR'S MANUAL		5. Report Date September 1981	6. Performing Organization Code
7. Author(s) William H. Wake and Garth A. Hull, editors		8. Performing Organization Report No. A-8336	9. Work Unit No. 663-80-02-01-00
10. Performing Organization Name and Address National Council for Geographic Education Western Illinois University, Macomb, Illinois, and Ames Research Center, Moffett Field, California 94035		11. Contract or Grant No.	12. Title of Report and Period Covered Conference Publication
13. Sponsoring Agency Name and Address National Council for Geographic Education and National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract			

This publication documents the Landsat C Educator's User's Workshop held in Santa Maria, California, on March 2-4, 1978. It is designed for instructors at all levels, elementary to graduate school, and for agency/industry in-house training. It serves as a workshop report, replicable workshop/course plan, and guidelines for surface truth field and laboratory instruction and learning evaluation.

17. Key Words (Proposed by Author(s)) EDUCATION		18. Distribution Statement Unclassified - Unlimited	
19. Security Classification of this report Unclassified	20. Security Classification of this paper Unclassified	Subject Categories Earth Sciences	
21. Security Classification of this paper Unclassified		22. Price NTIS	23. Price NTIS

